Appendix

B

BIGHORN NATIONAL FOREST

Final Environmental Impact Statement

for the

Revised Land and Resource Management Plan

Description of the Analysis

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Appendix B

Framework of the Planning Process

The revision of a forest plan is guided by the general planning process described in 36 CFR 219.12. This section discusses ten steps which led from the completion of the 1985 Forest Plan to the completion of a Revised Forest Plan. This was not necessarily a 'linear path', because some steps were revisited over the nearly five year Revision process.

Step 10 – Monitoring and Evaluation (Step 10 of the initial planning process)

The last step of the initial forest plan process is the first step in revising a forest plan. Annual monitoring and evaluation has been done since the forest plan was released in 1985. The monitoring reports have helped the Forest Supervisor identify several reasons to revise the forest plan.

Step 1 – Identifying the Purpose and Need

A series of six public meetings were held in November 2000 through January 2001 to ask the public to identify issues in the forest plan that needed revision. Local government officials, and state and federal agencies, were also involved at this stage. The feedback was screened into five possible categories of action:

1. Topics that required forest plan revision.
2. Other revision items that would not require a significant amendment but need to be addressed in the Revised Plan.
3. Topics related to plan implementation.
4. Topics outside the scope of a plan revision.

As a result of this scoping, five major revision topics for the forest plan revision were finalized:

- Biological and habitat diversity
- Roadless/Wilderness
- Timber Suitability and Management of Forested Lands
- Recreation and Travel management
- Special Areas

As the planning process continued, other changes not specifically related to the five major topics were also considered. However, the revision topics have become the primary focus of the forest plan revision effort.

Step 2 – Planning Criteria

During this step, the remainder of the process is outlined. As the revised plan was being prepared, several mid-course corrections were necessary, as models were not available or working properly, computer resources or assistance was not available, or public suggestions added additional considerations. The Bighorn National Forest used the 1982 version of the 36 CFR 219 planning regulations.

Step 3 – Inventory Data and Information Collection

A Geographic Information System (GIS) was used to build the database used in the plan revision. The type of data and information needed for the revision process was based on the revision topics, on what resources were available for data collection, and upon what data was available. The data was collected and assembled in a manner meaningful for addressing planning problems, as discussed later in this appendix.

Step 4 – Analysis of Management Situation (AMS)

This step determines the ability of the planning area to supply goods and services in response to society's demands. It provides background information for formulating a broad range of reasonable alternatives. The AMS focused on the revision topics and several of the models described in this appendix were initially developed during this step. Most of 2001 was devoted to compiling the Forest-wide and Geographic Area Assessments. The AMS was largely developed from the 1985 AMS, from the information and data collected and synthesized during the ASQ amendment process, and from the 2001 assessments.

Step 5 – Formulation of Alternatives

In late 2001, the steering committee was asked if they would like to participate in the development of alternatives. They chose not to, because they believed they did not have the technical expertise to do that. The steering committee preferred that the ID team draft alternatives and then provide comments on those. About this time, the "citizen's alternative" was presented.

An initial set of three alternatives was formulated by the interdisciplinary team following NEPA procedures. These three alternatives defined the extreme 'bounds' between commodity production and roadless/wilderness protection, with the existing Forest Plan in between. These alternatives were not well received when presented to the steering committee in July 2002. These alternatives were modified and three new alternatives were developed throughout the later part of 2002. In January 2003, six public meetings were held in the Bighorn area. The public was brought up to date on the revision process, and

was asked to review and comment on the alternatives. After a Regional Forester review in February 2003, the alternatives were set for the main effects analysis.

Throughout the remainder of 2003, the steering committee and the public were informed about various analyses and outputs. In December 2003, the steering committee was provided with an "Initial Effects Analysis", which summarized most of the effects of the alternatives. During January and Februrary, 2004, five days of steering committee meetings were held to review and improve the draft direction, the alternatives and the desired condition. Effects analysis modifications were made to incorporate these changes, and the set of alternatives that appear in the Draft Revised Plan was approved by the Regional Forester in March, 2004.

The Draft Plan and Draft Environmental Impact Statement were released for a 90 day public comment period on July 1, 2004. Ten public meetings were held, and over 18,000 comments were received. The steering committee and interdisciplinary team worked on improvements to the Draft Plan preferred alternative between October 2004 and the summer of 2005. Resource professionals from Wyoming State Forestry, Wyoming Game and Fish, and Wyoming State Trails were particularly helpful in development of the final Plan.

Step 6 – Estimated Effects of Alternatives

The physical, biological, economic, and social effects of implementing each alternative considered in detail were estimated and compared according to NEPA procedures. The level of accuracy of these estimates vary by resource area and analysis topic. This is due to, among other things:

- Forest Planning is a "coarse filter" approximation of the effects of a multitude of individual projects that will be conducted over the upcoming 10-15 year period. Individual project level planning will be a much finer resolution and accuracy.
- Data (including individual species occurrences, stand-level tree data, habitat conditions, etc.) at the 1.1 million acre scale is not as precise as the data that will be collected for individual projects.
- The resolution of mapping is inherently coarse at the Forest scale compared to project level planning. An example of this is the size of the existing Medicine Wheel National Historic Landmark. The establishment record sets the size as 110 acres, while the 1:100,000 scale Forest Plan management area map shows a NHL of 61 acres.

The interdisciplinary team based FEIS environmental consequences on past experience, monitoring, reviews by internal and external peers, and projected alternative outputs. The effects displayed in the FEIS use the best available science, but must be recognized as projections at a very coarse scale. However, even if the absolute value of projected effects are high or low, the relative value between alternatives is accurate because consistent, scientifically based, anlaysis techniques were utilized. This allows for a reasoned, rationale choice between alternatives.

Step 7 – Evaluation of Alternatives

Significant physical, biological, economic, and social effects of implementing alternatives were evaluated. The steering committee was especially effective in conveying to the Forest Supervisor and ID team the social and economic implications of National Forest management, and the dependency the local communities have on the Bighorn NF.

Step 8 – Preferred Alternative Recommendation

Between October 2004 and June 2005, the steering committee worked on improving the Draft Plan preferred alternative into alternative D-FEIS, which is the Final Plan. Evaluation criteria were the five revision issues; how well the alternatives addressed items such as the County Land Use Plans and the Healthy Forest Restoration Act; and, public input. The state and local government cooperators, the Forest Leadership team, and the public provided the Forest Supervisor with input throughout that period on what should be in the Final Plan. Alternative D-FEIS was recommended to the Regional Forester as the Final Plan.

Step 9 – Plan Approval and Implementation

The Regional Forester met with the Forest Supervisor, representatives from the steering committee, and many other people to receive input on selection of the Final Plan. He selected D-FEIS as Final Plan, with his rationale displayed in the Record of Decision.

Inventory Data and Information Collection

A Geographic Information System (GIS) was used to develop the forest plan revision database. A GIS database stores information about features located on a landscape. These features can range from natural features such as rivers and mountains to constructed features such as roads and buildings or even legal or administrative boundaries such as property lines or school district boundaries. The resulting database was used to analyze suitable timber lands, build the forest planning model (Woodstock/Stanley), describe the existing resource conditions, and perform other analyses for the revision. The following layers were developed using GIS:

- Integrated Resources Inventory (IRI) system – this layer contain physical, administrative, and vegetation data. These layers were completed in May 1999 and are further described in the Bighorn National Forest IRI Users Guide. The data has subsequently been updated as needed. The IRI data base includes three units:
    - The Common Land Unit represents relatively stable, terrestrial environment and is based on the integration of four components: geology, landform, soil and potential natural vegetation.
    - The Common Water Unit (CWU) contains basic watershed and water resource data.

- The Common Vegetation Unit (CVU) contains existing vegetation data, generally homogenous in dominant life form, species composition, percent crown cover, size, vertical structure, and crown condition.

- Management area prescriptions by alternative – these layers contain the management area prescriptions allocated for each alternative. There is one layer for each alternative. The information in this layer is shown on the management area prescription maps accompanying this document.
- Inventoried roadless areas – this layer contains the agency inventoried roadless areas on the Forest. (FSH 1909.12 Chapter 7)
- Recreation areas and cultural sites – this layer contains developed recreation sites, such as picnic grounds, campgrounds, summer home sites, and ski areas. The layer also contains the areas that are known to be highly sensitive to cultural resources over large areas.
- There are many other layers in the Forest data base, including, but not limited to: roads and trails, past activities, improvements such as fences and pipelines, land ownership, topographic and hydrologic features, administrative boundaries, etc.

Timber Suitability Analysis

Process to Determine Timber Suitability

Requirements to perform analysis of timber suitability are found in 36 CFR 219.14, 36 CFR 219.28, and FSH 2409.13, chapter 20. The "Region 2 – Process to Determine Timber Suitability and Standards for Display" was the procedure used with minor variations based on local factors.

Tentatively Suitable Timberlands Analysis is described in the "Region II Desk Guide for Forest Planning." The documentation of the process begins on page G.2 and the chapter is dated July 12, 2001. Major headings in this document represent the steps defined on pages G.8 and G.9. Additional documentation was drawn from the 1991 Environmental Assessment titled, "*Amendment to Restocking Standards, Bighorn National Forest Land and Resource Management Plan*" Rocky Mountain Region, R2, hereafter referred to as the "Restocking EA."

The documentation in the Restocking EA was forced to match the acreage listed in the official ownership records for the National Forest System. This acreage does not necessarily match the summarization of the sites listed in the RIS database and the RIS data summary does not match the calculation of area for the GIS coverage of RIS sites. Aside from these three sources, the Forest has also switched from the RIS data system to the Integrated Resource Inventory coverages. This document will attempt to report the results from each of these systems so that the reader can interpret the source of the changes in reported acreage.

A. **EA Acres** - These acreages match what was reported in the Restocking EA and are adjusted to sum up to the official acreage reported in "Land Areas of the National Forest System" published by the USDA Forest Service.

B. **ORA-RIS** – Each RIS site has an acreage that was calculated by using a Planimeter to measure the acreage of the mapped site. For a number of reasons, the oracle acres do not match the EA Acres.

C. **GIS-RIS** – the ArcInfo Geographic Information System calculates these acres. These numbers do not match Oracle or EA Acres but they use the same calculation method as the IRI statistics. 273 sites, totaling 8888 acres in the RIS coverage, do not have labels that can be linked to Oracle. These acreages are not included in category B or C statistics.

D. **IRI** – The Integrated Resource Inventory is an entirely new, complete inventory of the Forest, based on photo interpretation of 1992 aerial photos. IRI calculations include Common Vegetation Unit (CVU) data for vegetation, Common Land Unit (CLU) data for soils, Digital Elevation Model (DEM) data for elevation, slope, and aspect, Automated Lands Project (ALP) line work for ownership and withdrawn lands. These various sources are integrated through GIS operations.

1. National Forest System (NFS) Lands Identification of National Forest System lands is accomplished with the identification of the proclaimed boundary and identification of other land ownerships within the proclaimed boundary. Most of the Forest's primary Geographic Information System (GIS) coverages (or data layers) can be found on the Forest's computer.

Table B-1. National Forest System (NFS) acres using the different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Proclaimed National Forest	1115162	1122847	1111236	1112474
- Unlinked or No Data sites			- 8888	
- Other Ownership & Unknown	- 7491	- 7055	- 7079	- 7459
Net National Forest Ownership	1107671	1111961	1095269	1105015

2. Non-Forested Cover Types "Subtract non-forested cover types" … The Bighorn National Forest developed the "Key to Identification of Capable, Available, and Suitable Forested Land" in response to a Forest Plan Lawsuit. This process equates to steps numbered 1 to 3 in that key: "Water", (steps 1 and 2), "Site is developed for non-forest use" (step 3).

Water may be classified as "census water", timber component 001; or "non-census water", timber component 100.

The primary source for cover type information is the Common Vegetation Unit coverage. The explanation for the development of the LifeForm data is contained in the document, "forest_vs_nonforest.doc" in the planning files.

Table B-2. Forested and non-forested acres by different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Net National Forest Ownership	1107671	1111961	1095269	1105015
Non-forested areas	-435852	-435797	-427088	369667
Forested lands	671819	676164	668182	*735348

* The RIS data system only includes areas that are ten percent "occupied" by trees or greater. This ten percent is related to a fully stocked timber stand. The IRI data measures the percent of ground covered by timber canopy, shrubs and forbs, not the basal area of trees. Forested status in IRI is then determined by a formula relating the percent coverage of the various vegetative components. It appears that the IRI definition of Forested Lands is more liberal than the RIS definition.

The Regionally recommended analysis process includes removing the area that is non-productive because of roads and streams. The following table specifies the distance from centerline for roads and perennial streams. Roads and streams will be removed as the last step in the tentative suitability process.

Table B-3. Buffer distance (in feet) by road level and stream order.

Road level	Buffer distance from centerline
1	8
2	8
3	15
4	20
5	20
Highway	30
Stream order	**Buffer distance from centerline**
1	1
2	2
3	3
4	5
5	10
6	10

3. Congressional Designation Lands that have been set aside as Wilderness, Research Natural Areas, or other congressionally designated uses, are removed from consideration for timber suitability. For this analysis the Cloud Peak Wilderness, Bull Elk Park Research Natural Area, and the Shell Canyon Research Natural Area are included as "withdrawn."

Table B-4. Areas withdrawn from timber suitability using the different systems.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Forested lands	671819	676164	668182	735348
Forested Wilderness	N/A	N/A	64015	84089
Forested Bull Elk Park	N/A	N/A	524	900
Forested Shell Canyon	N/A	N/A	0	580
TC 310 @ Medicine Wheel	0	N/A	226	0
Forested, withdrawn or no TC	-65003	-68311	-64764	-85569
Forested, not withdrawn	606816	607853	603417	649779

N/A – No break down was available in this category.
Land around the Medicine Wheel does not belong in this category.

4. Non-Industrial Wood Timber lands that have cover types that are not useful as industrial wood fiber in this area are excluded from the tentatively suitable land base. The species that are useful in this area are lodgepole pine, ponderosa pine, Douglas fir, subalpine fir and Engelmann spruce.

Table B-5. Non-industrial and industrial cover type acres using different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Forested, not withdrawn	606816	607853	603417	649779
Aspen (TAA – 901)	N/A	5685	5626	9650
Cottonwood (TCW - 902)	N/A	127	151	397
Limber pine (TLI - 903)	N/A	17676	17683	14182
“Pinyon/Juniper” (TPJ - 904)	N/A	1202	1225	2842
Non-forested types	0	141		0
Total Non-industrial Species	-27196	-24690	-24685	-27071
Douglas Fir (TDF)	N/A	84662	84293	98968
Lodgepole pine (TLP)	N/A	344697	341818	315185
Ponderosa pine (TPP)	N/A	14928	14616	18513
Spruce and Fir (TSF)	N/A	138876	138006	177219
Other TC 900 sites	N/A	-4167	-4165	12824
Total Industrial wood species	579620	578996	574568	622708

5. Irreversible Damage Irreversible resource damage in RIS is identified as Timber Component 722. There are several versions of the documentation for this item, each one attempts to identify sites based on the combination of soils and slope. The Restocking EA indicates that “Forest specialists identified certain areas that are prone to mass failures such

as slumps or slides using standard road building and logging methods currently practiced on the Forest." The soil and slope combinations listed in the 1993 "Draft Suitability Key" are used in conjunction with the "landslide" coverage from the IRI product to produce the IRI column below. Even though it appears that many additional acres were removed with this process, a close review shows that most of the acres removed due to soil and slope combinations are on inoperable slopes with conventional harvesting technologies.

Table B-6. Irreversible damage acres by the different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Total Industrial wood species	579620	578996	574568	622708
Soil and slope combinations	N/A	N/A	N/A	73949
Landslide coverage area	N/A	N/A	N/A	26147
RIS Component 722	-13920	-14236	-14031	N/A
Industrial wood on stable soils	565700	564760	560537	522612

6. Restocking Assurance Assurance of restocking was the focus of an amendment to the Bighorn National Forest's 1985 Forest Plan. Accordingly, greater detail is included in this criteria and that detail is included in the table below.

For the IRI analysis, elevation and aspect information was drawn from a Digital Elevation Model with 30-meter resolution. This data results in numerous small polygons, which were removed if they were less than 5 acres.

Table B-7. Restocking assurance acres by the different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Industrial wood on stable soils	565700	564760	560537	522612
Sites above 9200 feet	55225	56318	56329	58304
Sites below 7400 feet	76133*	81049	80245	80988
7400'–7900' on S or W slope	18149	17180	16993	19061
Bottle or Foxton Soils	4782	6576	6575	2303
33% or more surface rock	2841	23591	22896	5518
Sub-Total	-157130	-184702	-183038	-166174
Site-specific additions	+2086	+N/A**	+N/A**	
Site-specific deletions	-16459	-28694	-28433	
Industrial, assured restocking	394197	351364	349067	356438

* I assumed that the number "176133" in the Restocking EA was a typographical error.
** Site-specific additions could not be separated out in this process. Site-specific deletions were counted as any sites that had made it through the key, but were still classified as timber component 710 in RIS.

7. Inadequate Response Information Lands that are excluded with this step include sites where the information that is available cannot adequately predict the sites response to timber management practices. Although some of our suitability keys disagree, the EA titled, "Amendment to Restocking Standards, Bighorn National Forest, Land and Resource Management Plan" includes the following statements on page E-16:

"Category 7 - Lands for which current information is inadequate to project responses to timber management. This includes Douglas-fir stands on south west aspects. The Forest Service has had more time to evaluate management on ***these sites*** *since the original Forest plan suitability analysis and has found that regeneration is not predictable. Douglas-fir is a species used by industry and on many sites regeneration can be assured in the five-year time limit."* (emphasis added)

In the wording, which is quoted above, the words "these sites" is assumed to refer to "stands on south west aspects". Aspects included in "south west" are a DEM generated aspect >= 180 and aspect <= 270. (That includes everything between due south and due west.)

Ponderosa pine is not mentioned, so all of the Ponderosa acres that have passed the other filters are removed here.

Table B-8. Inadequate response acres using the different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Industrial, assured restocking	394197	351364	349067	356438
Douglas fir on south west				6516
Ponderosa Pine	-42281	-39459	-39324	302
Historic Tentatively Suitable	351916	311905	309743	349620

8. Non-Forested Sites – Revisited The latest Regional process describes removing a buffer of non-productive land around highways, Forest Development Roads, and streams. These buffers consist of the highway right-of-way (66 feet on either side of the center line), the FDR road profile (8 feet on either side of the center line), and an average stream width (3 feet on either side of the center line for a perennial stream). See Table B-3 for the earlier buffer method.

Table B-9. Non-forested buffer acres of roads and streams using the different sources.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Historic Tentatively Suitable	351916	311905	309743	349620
Road buffered area				1626
Stream buffered area				475
Total buffered areas				-2101
Current Tentatively Suitable	351916	311905	309743	347519

Analysis and Implications

There can be no doubt that many of the suitability categories have seen changes with the change in the data sources. There was a lot of effort that went into the timber component data in RIS.

The conversion to GIS generated acreages has separated our calculated acreage from our declared acreage. The declared acreage is based upon an accumulation of surveying data known as Public Land Survey Sections. The GIS generated acreage depends upon cartographic calculations that are generated from geographic projections of a round earth on a flat surface.

National Forest System Lands This data is dependent upon the Automated Lands Project (ALP). ALP is designed to follow the Public Land Survey Sections (PLSS) and the National Forest boundary follows these lines, which should be tied to surveying monuments on the ground.

Non-forested cover types Cover type calculations are based on an interpretation of the stand components in the Integrated Data Solutions, Common Vegetation Unit data (CVU). The RIS data system only includes areas that are ten percent "occupied" by trees or greater. This 10% is related to a fully stocked timber stand. In the IRI data, we only measured the timber canopy, not the basal area of trees. It appears that the IRI definition of Forested Lands is more liberal than the RIS definition.

Non-industrial wood Some stands may have an incorrect cover type label from the CVU photo interpretations. Other changes may be caused by modifications in the way that mixed stands are classified to fit cover types.

Irreversible damage There were many discrepancies between the various sources that could have been used for the "irreversible damage" component. The primary options considered were the sites in RIS that were previously classified as timber component '722', a 'landslide' coverage that was generated in conjunction with our "Common Land Unit" (CLU) data, and a group of soil and slope combinations that were listed in the 1993 "Draft Suitability Key". In the end we used the landslide and "Key" data. Many sites that were classified as timber component 722 in RIS were in areas that had poor regeneration, but were not areas where irreversible damage occurred following our existing harvests.

Restocking assurance – elevation and aspect The restocking classification has historically been defined based on elevation, aspect and soils. Many of the soils are identified because they are well drained and tend to be droughty. Data sources, and some site-specific changes, that were not available during the era of the RIS database have changed the way that we look at restocking assurance.

Restocking assurance – percent rock The percent rock analysis was based on soil types. There are several "unmapped components" to a soil classification and the soils that were excluded at this step may have had excessive rock in any of the top three soil components. The definition of excessive rock that I used was the presence of a "V" as the third character of the "surface modifier" code. According to Eric Winthers, past soil scientist for the

Rocky Mountain Region, the "V" code implied the surface modification affected 35 to 60 percent of the soil texture.

Inadequate response information At present, all Douglas fir and Ponderosa Pine are excluded in this category. Documentation in the restocking Environmental Analysis (November, 1991) indicates that only Douglas fir stands on "south west" aspects are unsuitable. Sites on south to west aspects are given a separate code from other Douglas fir or Ponderosa Pine.

Table B-10. Reference Codes used in GIS analysis

000	Other Ownership & Unknown	714	Bottle or Foxton Soils
001	Water bodies over 40 acres	715	33% or more surface rock
100	Water bodies under 40 acres	722	Irreversible resource damage
200	Non-forested areas	723	Soil and slope combinations
201	Highway buffered area	724	Landslide coverage area
202	FDR buffered area	740	Douglas fir on SW slopes
203	Stream buffered area	742	Ponderosa Pine
310	Forested Wilderness	901	Aspen (TAA – 901)
311	Forested Bull Elk Park	902	Cottonwood (TCW - 902)
312	Forested Shell Canyon	903	Limber pine (TLI - 903)
711	7400' – 7900' on S or W slope	904	"Pinyon/Juniper" (TPJ - 904)
712	Sites below 7400 feet	998	Tentatively Suitable Douglas fir
713	Sites above 9200 feet	999	Tentatively Suitable Timberlands

Restocking Analysis Review

The Forest reviewed the criteria used to previously identify lands where restocking could not be assured within five years follows final harvest.

The criteria used to identify lands incapable of regenerating within five years of final harvest are:

1. Elevations above 9200 feet were identified because of low temperatures; short growing seasons, and rocky soils. Monitoring has not identified a need to change this. The analysis process describes how this was modeled with the new Forest database.
2. Elevations below 7400 feet were identified because of lack of precipitation, high temperatures, and droughty soils. The analysis process describes how this was modeled with the new Forest database.
    a. Monitoring has identified that elevation doesn't always reflect precipitation accurately. Precipitation maps and field monitoring are still necessary at the site-specific analysis phase to evaluate this factor.
3. Elevations between 7400 and 7900 feet on south and west aspects were identified because of lack of precipitation, high temperatures, and droughty soils. Monitoring

has not identified a need to change this. The analysis process describes how this was modeled with the new Forest database.

4. Soil Series – The Foxton and Bottle soil series are soils that have severe limitation for reforestation. The analysis process describes how this was modeled with the new Forest database. Monitoring did identify some concerns with this criteria:
    a. On the ground observations have shown a concern with the suitability criteria of eliminating all of soil map unit 38 (Sapphire-Bottle-Foxton). The Soil survey of the Bighorn National Forest, Wyoming (1986) is the basis for this discussion, it describe the Bottle and Foxton soils as having severe limitations for regeneration due to the soils moisture holding ability, with the Bottle soils too well draining, and the Foxton holding the moisture too tight. The Bottle and Foxton soils are of moderate production (32 and 35 cubic ft./acres/year). However, the largest proportion of the soil series is Sapphire at 35%, with Bottle comprising 30%, Foxton 20%, and 15% inclusions of Cloud Peak and Rock outcrops.
    b. The Sapphire soils are the third most productive soil, producing 53 cubic ft./acres/year, with moderate limitations for reforestation. Monitoring has shown these soils to regenerate and produce well, with natural regeneration, with lodgepole saplings putting on over a foot of height growth each year.
    c. The current soil survey doesn't separate out these soil types from the general soil map unit 38 (Sapphire-Bottle-Foxton). Because 50% of the soil map unit has severe limitations for reforestation, in the suitability analysis, the entire soil map unit was deemed unsuited for inadequate response. As a result, an estimated 3,700 acres of Sapphire soils were considered unsuited out of the total map unit estimate of 10,542 acres.
    d. Field observations have identified Sapphire soils in the Ghastly, Garland, Dayton Gulch, and Fool creek sale areas that have shown good regeneration. Because of this new information, these areas were not dropped in step 6 of stage I suitability analysis. If during site-specific analysis areas of Bottle and Foxton soils are identified, a decision to remove these areas from suitability can be made at that time.
5. Percent rock – 33 percent or more surface rock physically limits soil surface available for seedlings establishment. Monitoring has not identified a need to change this. The analysis process describes how this was modeled with the new Forest database.

At the Forest Planning scale, assumptions are made which may not apply to on the ground conditions. Individual site-specific decisions based on field reviews may modify these assumptions and make site-specific changes to timber suitability.

Display of Timber Suitability in the FEIS

A detailed description of the analysis process used in determining tentatively suitable timber lands is described above. A summary of the results from this analysis is included in

the Timber Environmental Consequences section of Chapter 3, with a reference to Appendix B for more information.

Table B-11 compares the various tentative timber suitability analyses for the Bighorn Forest since 1975 to the current Plan revision. Maps of the suitable timberlands on the forest are in the project file.

Stage III suitable land determination is displayed in Table B-12. Acres removed for multiple use objectives include: i.) Management area with only management areas 5.11, 5.12, 5.13, 5.4, 5.5 and MW containing suited lands, ii.) In management area 5.4 blocks of contigious timber had to be greater than 250 acres to be suited., iii.) Lands within 100' of the riparian were removed and iv.) In management area 5.4 lands within 100' - 300' of perennial streams were removed.

All lands that made it this far were operable with current conventional harvesting technologies, so no acres were removed for "logging methods".

In management area MW, what was designated as suited lands in the 1985 Forest Plan continue to be designated suited. The Historic Preservation Plan did not change timber land suitability in this area.

Table B-11. Historical review and summary of lands suited for timber production in GIS acres.

Historical Three Stage Suitability Analysis

Classification Categories	1975 Timber Management Plan Acres*	Forest Plan 1985 Acres	Reanalysis 1991 Acres	Reanalysis 1993 Acres	2003 Reanalysis Acres, IRI	2005 Reanalysis Acres, IRI
1. Total National Forest Land	1,107,342	1,107,670	1,107,671	1,107,671	1,105,015	1,105,015
Stage I						
2. Non-forested land (includes water)	-419,059	-419,388	-435,852	-437,577	-369,667	-369,667
a. Road buffer					-1,604	1,626
b. Stream buffer					-234	-476
3. Forested land (1-2)	688,283	688,282	671,819	670,094	733,509	733,247
4. Forested land withdrawn from timber production.	-19,903	-31,260	-65,003	-63,839	-85,570	-85,570
5. Forested land not capable of producing crops of industrial wood.	-127,586	-127,586	-27,196	-25,574	-27,071	-27,071
6. Forested land physically unsuitable.						
a. Irreversible damage likely to occur.	0	0	-13,920	-59,448	-116,905	-100,095
b. Cannot be restocked within 5 years.		-103,499	-171,503	-189,957	-156,417	-166,174
7. Forest land-inadequate response information.	-152,057	0	-42,281	-34,640	-6,957	-6,817
8. Lands tentatively suited for timber production (3-4-5-6-7)	388,737	425,937	351,916	296,636	340,589	347,519
Stage II						
Analysis of benefits and costs for timber production.	0	0	0	0		
Stage III						
9. Forested land not appropriate for timber production (this is a tiered filter process**)						
a. Multiple-use objectives		-62,100	-8,832	-5,165		
b. Other management objectives.	0	0	0	0		
c. Economic efficiency (logging methods)	-142,806	-97,398	-81,022	-19,411		
10. Lands suitable for timber production (8-9)	245,931	266,439	262,062	272,060		

* Definitions of suited lands were different in 1975; this is included for reference only.

** See footnote in following table for description of the tiered filter process.

Table B-12. Summary of lands suited for timber production by alternative.

	Alternative					
	A	**B**	**C**	**D-DEIS**	**D-FEIS**	**E**
8. Lands tentatively suited for timber production (3-4-5-6-7)	347,519	347,519	347,519	347,519	347,519	347,519
Stage II						
Analysis of benefits and costs for timber production.	0	0	0	0	0	0
Stage III						
9. Forested land not appropriate for timber production (this is a tiered filter process**)						
a. Multiple-use objectives						
i. Acres not in 5.11, 5.12, 5.13, 5.4 and 5.5	-64,919	-223,061	-289,378	-161,459	-149,575	-12,598
ii. 5.4 in 250+ acre contiguous blocks	0	0	0	0	0	0
iii. 100' Riparian Buffer	-20,241	-9,049	-3,165	-13,337	-13,676	-24,871
iv. 100' - 300' Perennial Stream Buffer	0	0	0	0	-1,339	-4,496
b. Other management objectives. (M.A. MW)	0	2,347	2,347	2,347	2,347	2,347
c. Economic efficiency (logging methods)	0	0	0	0	0	0
10. Lands suitable for timber production (8-9)	**262,359**	**117,756**	**57,323**	**175,070**	**185,277**	**307,901**

Suited lands by Management Area	**Alternative**					
	A	**B**	**C**	**D-DEIS**	**D-FEIS**	**E**
5.11 Forest Vegetation Emphasis	79,829	41,325	51,214	71,815	31,105	34,304
5.12 Rangeland Vegetation Emphasis	47,964	16,205	3,763	32,748	13,084	29,144
5.13 Forest Products	134,556	57,879		68,160	97,684	70,388
5.4 Wildlife Habitat - Forest Products					65,780	19,907
5.5 Dispersed Recreation - Forest Products					97,901	29,186
MW Medicine Wheel		2,347	2,347	2,347	2,347	2,347
Total	**262,359**	**117,756**	**57,323**	**175,070**	**185,277**	**307,901**

**Tiered filter process: Subtract acres identified in 9ai from the tentative suited base, then subtract acres in the 100'riparian buffer (9aiii) and the 300' (9aiv) perennial stream buffer from the tentative suited base to arrive at *Item 10. Lands suitable for timber production*.

Timber Planning Model

Forest plan modeling was accomplished using a number of resources. Some work was done in-house at the Forest, the yield tables were completed by personnel at the Fort Collins WO detached office, and the harvest schedule modeling was done by a private contracting firm. The contractor used Remsoft's *Woodstock*© timber model. Complete documentation is in the project record.

Woodstock© was used to schedule timber harvests by decade for the next 15 decades. This long planning horizon assures a sustainable yield into the future. Most of the affects analysis used data from the first five decades, averaged on a decadal or annual average.

Stratification Land stratification is the process of identifying a set of attributes, or strata, to use in defining the land base. This is done to organize the forest land base into logical subunits that respond similarly to management actions. Forested land was stratified by cover type, size class and density as these match the habitat structural stages used in affects analysis. Additional data included watersheds, scenic integrity objectives, road construction needs, existing transportation system, stream courses, and Lynx habitat.

Silvicultural Prescriptions in the Model Silvicultural systems were set up for the cover types harvested. In lodgepole pine, these included even aged systems of clearcuts and two-step shelterwood, and uneven-aged management using group selection on a 20 year cutting cycle. In both the spruce-fir and Douglas for cover types these included three step shelterwood and uneven-aged management using individual tree selection on a 20 year cutting cycle. Yield tables were developed using the Forest Vegetation Simulator (FVS) for these prescriptions and used in the Woodstock© model.

Culmination of mean annual increment (CMAI) calculations was based on cubic merchantability specifications included in the Forest Plan for sawtimber and Products Other than Logs (POL).

Costs and Revenues in the Model Cost and revenues used in the model were averages of actual past costs and revenues from the Bighorn Forest. Conventional harvest systems were included. Un-conventional systems such as cable, helicopter, cut to length were considered, however previous analysis done in support of the 1994 ASQ plan amendment, and reviewed for this analysis, showed that while there may be areas that could utilize these systems, they are too small and scattered to be practicable over the long term for timber production objectives. These systems may be utilized when managing for other than timber resource objectives.

A summary of the costs and benefits used in the model are included in the project file.

Model Objective The model was run with an objective to maximize net present value (NPV).

Model Constraints Several constraints were developed for the model in response to management requirements in the NFMA regulations (36 CFR 219.27) and goals, objectives, strategies, standards and guidelines developed for the alternatives. The following constraints were applied to all alternatives.

Timber

For Lands suited for timber production in management areas 5.11, 5.12, 5.13, 5.4, and 5.5 use the following as a guide. Constraints may alter the amount of even vs. uneven aged management.

Table B-12. Management areas 5.11, 5.12, 5.13, 5.4, and 5.5 cover type/harvest guidelines.

Cover Type	Spruce fir, Douglas fir	Lodgepole
Clearcut	None projected.	Used to meet the 5% early habitat structural stage diversity guideline
Shelterwood	Used to regenerate stands without creating early habitat structural stages or in stands where maintenance of elk security was not required.	
Group and Individual tree Selection	Used to meet SIO and elk security constraints	Used to meet SIO and elk security constraints

- Projected post sale treatments (Based on past and expected actions)
  - Clear cut harvest includes: Site Preparation, 75% broadcast burn, 15% pile and burn, 10% none. 50% Planting
  - Shelterwood harvests include: Prep cuts. – No post sale work. Seed cut. Site Preparation, 15% broadcast burn, 75% nothing, 15% Planting
  - Un-even aged selection
    - Group Selection includes 20% TSI, 5% Planting.
    - Individual Tree Selection, 10% TSI.
- Other Constraints :
  - Long term sustained yield, and even flow. (36 CFR 219.16)
  - Ending inventory constraint. While this was utilized in the draft analysis, a review pointed out that given that the Forest is over-mature, with more volume per acre now than it would have at regulation, this constraint had no legal backing, was deemed redundant and overly restrictive, and therefore was not included in the final analysis.
  - Rotation age should be at 95% of Culmination of Mean Annual Increment. (36 CFR 219.16)
  - Even-aged cut block size. (36 CFR 219.27) includes: Final harvests will not exceed 200 acres (clearcut,), minimum harvest site is 5-10 acres, logical harvest units must separate openings created with even-aged management. (Leave same acreage between units as cut acreage),
  - Opening is no longer an opening in 2-3 periods using FVS runs, based on: (Forest wide silviculture guideline #4)

- In Low SIO stocking is 7 foot tall with 300 trees per acre.
- In Moderate SIO stocking is 25% of the height of the adjacent stand with 150 trees per acre.
- In High SIO stocking is 50% of the height of the adjacent stand with 150 trees per acre.

- Financial, allow 25% cost overrun on road costs vs. timber revenues per decade. This was chosen to reflect the uncertain market conditions and to allow for future efficiencies in harvest operations to be realized.
- Maximum percentage of Spruce/fir harvest. Was used in the draft, but found not be binding, and was not included in the final.

Scenery

- Constrain harvest method by SIO
  - High and moderate SIO limited to no less than 50% uneven-aged management, group or individual tree selection.
  - Low SIO has no limitations.

Heritage

Cultural Landscapes (9 identified). In the draft analysis visual constraints were applied to the cultural landscapes, however, further analysis showed this to be unnecessary for the resource needs and was not used in the final analysis.

Wildlife

Elk security. (Forest wide wildlife guideline #6) includes: No net loss of elk security from management activities. Harvest is allowed in elk security, if post harvest condition still meets Elk Security definition. To achieve this guideline timber harvest in elk security was limited to uneven-aged management. All new roads would be closed after harvest. There was no limitation on % of Elk Security block entered. While it is recognized that elk security can move about the landscape as trees grow and roads are closed or opened, to model these changes was beyond the scope of our analysis, therefore elk security acres remained static over the planning horizon.
Snags and coarse woody debris guidelines were incorporated into the growth and yield tables, and did not need to be further modeled.

Lynx

- After initial analysis, the lynx standards and guidelines were determined to be non-binding to the model.
- If Lynx standards and guidelines are included in the Plan, in Lynx habitat pre-commercial thinning would be allowed only when stands no longer provide snowshoe hare habitat (e.g., self-pruning processes have eliminated snowshoe hare cover and forage availability during winter conditions with average snow pack). This is reflected in the bare ground yield tables which will not schedule TSI until height to crown is 2 feet. (Timber management project planning standard #3).

Biodiversity (Forest wide biodiversity guideline #3)

- Schedule harvest to obtain HSS diversity <u>by geographic area</u> to create:
  - Early structural stages, 5% in HSS 1 or 2.
    - Old Growth HSS, was allocated prior to first period and kept as old growth throughout the planning periods. First choice for designation will be non-suited lands.
      - In cover types except SF, 10% in HSS 5, in Spruce/fir, 15% in HSS 5.
        - Percentage by cover type will be proportional to the occurrence of that cover type in the geographic area that meets definitions below. If there is insufficient acres use closest surrogate.
        - Lodgepole HSS 5 = 4a, b, c and 151+ years old.
        - Spruce/fir, Doug Fir HSS 5 = 4c and 200+ years old.
        - Ponderosa, Limber pine HSS 5 = 4a, b and 161+ years old.

Spatial Analysis Spatial constraints are evident in the guidelines for size of created openings, and when an opening is no longer an opening (described above). The green-up time, or time between harvest and when a clearcut is no longer an opening, used data from the FVS yield tables.

- Spatial analysis was performed using the *Stanley*© extension of the *Woodstock*© model.
    - Only clearcut activities were modeled as other regimes did not create openings.
    - Created openings could be up to 200 acres.

Benchmark Comparison of Model Outputs

- **Sensitivity and Benchmark runs were made for identified issues using alternative D-FEIS, except where noted:**
    - **Maximize net present value;** results were similar to preferred alterative.
    - **Maximize timber volume,** utilized the tentatively suited timber lands, and was only constrained by long term sustained yield and even flow.
    - **Stage II economic analysis,** was completed and is in the project record. The most cost efficient silvicultural method is clearcutting.
    - **Elk Security,** results were similar among sensitivity variations.
    - **Greater Water Influence Zone (100-300'),** results were similar among sensitivity variations.
    - **Road Cost vs. timber value,** results were similar among sensitivity variations.
    - **Scenic Integrity Objectives** results were similar among sensitivity variations.
    - **Old Growth,** results were similar among sensitivity variations.
    - **Early Habitat Structural Stage (HSS 1, 2)** results were similar among sensitivity variations.
- The outputs for this model were also compared with the results of the 1985 Forest plan projections, actual accomplishments, and projections from the unimplemented 1994 ASQ EIS amendment.

Allowable Sale Quantity (ASQ), and Total Sale Program Quantity (TSPQ)

Allowable Sale Quantity

Allowable sale quantity (ASQ) includes volume expected to be offered from the lands identified as suitable for timber production. This volume is expressed in cubic feet, cunits (100 cubic feet) or MCF (thousand cubic feet), and includes material 5" dbh and greater (POL and Sawtimber). Spatial results from the *Woodstock*© model, described above, were used to estimate the volume that could come from the suited lands, except for those within the MW management area. To calculate the volume that could be offered from within the MW management area, a pro-rated volume per acre, from the *Woodstock*© model was applied to the suited acres within the MW management area, at the time the Historic Preservation Plan (HPP) was signed. Total ASQ includes the spatial *Woodstock*© results described above, and the volume from the MW management area. For display purposes the ASQ is separated into POL and sawtimber portions, and an approximate equivalent in million board feet (MMBF) is also shown.

Total Sale Program Quantity

Total sale Program quantity (TSPQ) includes all the volume expected to be offered from the Forest given expected budgets in the foreseeable future from lands suitable for timber production contributing towards ASQ and from Other Vegetation Management (OVM) on unsuited lands. Total sale quantity includes volume from sawtimber, Products Other than Logs (POL), personal use firewood, post and poles from all sales and permits. The ASQ portion was calculated based on anticipated budget levels utilizing past budgets as a guide. The OVM portion was based on estimates of anticipated acres of treatment prorated at the average volume per acre for suited lands. Personal use firewood is based on past recent history.

Fire Hazard and Risk Analysis

Fire Hazard Analysis

The potential for wildland fire is measured in terms of fire hazard and resistance to control. In an effort to model fire behavior, fire managers have developed fire behavior modeling systems, of which the NFDRS (National Fire Danger Rating System) and the FBPS (Fire Behavior Predication System) models are among the most commonly used.

NFDRS is used as an indicator of potential fire behavior across analysis areas, which often include many thousands of acres. FBPS is useful for more site-specific applications. The FBPS model illustrates the differences in fuels and how they react to such factors as wind, humidity, and topography in natural or management ignited fire.

Output from the FBPS can be rated based on relative resistance to fire suppression activities. The classifications used are usually low, moderate, high, and extreme and are routinely a function of flame length, rate of spread, or intensity. Low resistance to control typifies fires that are relatively easy to suppress in the shortest time frames while high resistance fuels are usually older age conifer fuel types or shrub fuels with significant fuel loadings which can produce extreme flame lengths and fire intensities that exceed the capability of direct fire suppression actions.

In an effort to model fire hazard on the Bighorn NF, a forest-wide analysis was completed using GIS (Geographic Information System), FlamMap (Finney 2000) and RMRIS (Rocky Mountain Resource Information System), and CVU (Common Vegetative Units). FlamMap is a computer program that produces fire behavior values (e.g., rates of spread, flame lengths) based on weather and physical characteristics of the ground and allows the user to produce fire behavior maps. For this analysis, the flame length value was used due to the relationship between flame length and fire intensity and their implications to fire suppression.

The objective of this hazard analysis is to quantify flame length, using 90th percentile weather[1], across the landscape. The resulting flame lengths are then grouped into four categories: (1) low – flame lengths four feet or less, (2) moderate – flame lengths greater than four feet and less than or equal to eight feet, (3) high – flame lengths greater than eight feet and less than or equal to ten feet, and (4) extreme – flame lengths eleven feet and greater. These groupings are commonly used fire behavior thresholds.

Methods for Determining Fire Hazard GIS was used to create a fuel model layer (collection of fuel properties; e.g., fuel loading, fuel bed depth) based on the standard Fire Behavior Prediction System (FBPS). Fuel models are simply tools to help the user realistically estimate fire behavior {Anderson 1982}.

[1] 90th percentile weather represents days when the fire danger is very high to extreme—a combination of low humidity, high temperature, and high winds.

Prior to running FlamMap, crown base height (CBH), crown bulk density (CBD), canopy cover, and stand height were determined for each fuel model identified on the forest using common vegetative unit (CVU) stand data. Crown (canopy) base height is an optional raster theme in FlamMap, however, it is important for determining transition from surface fire to crown fire. Crown (canopy) bulk density is also an optional raster theme, but is needed to determine the characteristics of crown fires. Stand height is an optional spatial data theme that is used for computing wind reduction to midflame height and spotting distances from torching trees.

Canopy cover is a required theme for computing wind reduction factors and shading in the optional dead fuel moisture model. Canopy cover is measured as the horizontal fraction of the ground that is covered directly overhead by tree canopy. It is not the same as crown closure, which refers to the ecological condition of relative tree crown density. Due to the number of RIS location/sites across the forest and the time required to calculate CBD, CBH, canopy cover, and stand height, data for sites were averaged for each fuel model and cover type. CBD, CBH, canopy cover, and stand height was then calculated for each representative stand.

FlamMap also requires live and dead fuel moistures for each fuel model as well as wind speed and direction. A historic weather analysis was completed to determine these variables. Historical weather data was collected from the Burgess, Hunter, Schoolhouse Park, and Mill Creek Remote Automated Weather Station (RAWS) for the period from 1969-2002. Weather data was downloaded from the Weather Information Management System (WIMS) data base and processed with Fire Family Plus (USDA Forest Service, 2000) using an annual filter of June 16 through October 5 which represents the Bighorn fire season. It should be noted this percentile can be approximated to seasonal fire behavior nomenclature, where 90th percentile equates to drought conditions. Average windspeed was calculated by FireFamily Plus. Note that surface wind speed is often the most critical weather element affecting fire behavior and fire danger. It is also the most variable and, consequently, the hardest to evaluate.

Air moving across the surface of the land constantly changes in both speed and direction. Over a period of time, one observes a series of gusts and lulls in the wind speed. Winds that persist for 1 minute can affect gross fire behavior, including rate of spread and fireline intensity. Momentary gusts, on the other hand, have little effect on the overall rate of spread or intensity. However, they can produce large, temporary fluctuations in flame height and can easily trigger crowning or throw showers of embers across the fireline. Both probable maximum one-minute gust and the probable momentary gust are displayed. For the analysis, both the probable maximum one-minute speed and probable momentary gust were used as both play important roles in fire behavior. Probable Maximum 1-minute windspeed was used because winds that persist for one minute can affect gross fire behavior, including rate of spread and fireline intensity, thereby affecting surface to crown fire initiation and transition.

Once all the input data had been determined, FlamMap was run and a map generated, indicating flame lengths across the landscape. This map was then exported out to arc-info

in the ASCII/raster format and processed in arc-grid, where flame length per number of acres (percent of vegetated area by flame length) was determined.

Limitations of the hazard analysis (1) Since CBD, CBH, canopy cover, and tree height were calculated on the "average" site for each cover type and subsequent fuel model, the analysis underestimates fire behavior at the upper end for each fuel model, especially as it relates to surface to crown fire initiation, transition and canopy fire behavior. As a result, the number of acres in the extreme, high and moderate hazard classes are underestimated, with acreages the latter two being most effected by surface to crown transition and canopy fire behavior.

(2) The above analysis will not account for any future changes in vegetation due to insect epidemics or disease outbreaks.

(3) This is a broad scale assessment of fire hazard that is not intended to employ the site specific detail used in project level analysis. Analysis for project level planning which uses detailed and site-specific information will yield more accurate fire behavior outputs.

Fire Risk Analysis

To further evaluate fire's relationship to overall forest management and protection, fire hazard was related to risk. Risk relates to the source and number of ignitions, which can result from either human-caused or natural caused (i.e. lightning) ignitions. Although fire risk is simple to calculate, it is difficult to predict, especially with human-caused ignitions.

Fire risk is the simple measure of fire starts on a 1,000-acre basis per ten year period (per decade). The fire risk value corresponds to a likelihood of fire starts per 1,000 acres per decade. The following are risk ratings and range of values used to categorize risk.

Low Risk: 0 to 0.49 – This projects a fire every 20 or more years per thousand acres.

Moderate Risk: 0.5 to 0.99 – This projects one fire every 11 to 20 years per thousand acres.

High Risk: ≥ 1.0 – This level projects at least one fire every 0 to 10 years per thousand acres.

This analysis used all data available in the historical fire occurrence database. This database contains fires from 1970 to 2004 on which suppression action was taken and a Individual Fire Report (FS-5100-29) completed and submitted.

In an effort to quantify risk for this analysis, fire occurrence records were obtained and processed in GIS. The fire locations were plotted and overlaid on a Forest map. Three geographic areas were identified, where fire occurrence appeared to be somewhat similar and homogeneous throughout the area. Fire risk was then calculated for each of the three areas and for the forest as a whole based on historic fire occurrence.

Fire Regimes and Condition Classes The fire regime groups and conditions class classifications were determined from Forest Integrated Resource Inventory (IRI) and Common Vegetative Unit (CVU) stand polygon data. The classifications were based on definitions presented by Wendel Hann and David Bunnell in *Fire and Land Mangement Planning and Implementation Across Multiple Scales, 2001.*

Fire Use and Appropriate Management Response Fire has and will continue to play a role in the structure, occurrence and condition of vegetative communities on the forest. Under the current Bighorn Land and Resource Management Plan (1985), the only management response to an unplanned wildfire ignition is a suppression strategy. One of the objectives of this revision is to establish a range of acceptable appropriate management response (AMR) actions. The draft EIS assigned to each Management Area prescription in the revision, a menu of AMR actions (direct control, perimeter control, and/or prescriptive control). During the period of time between the draft and final EIS, the Forest Fire Management Officer, Zone Fire Management Officers, and Zone Assistant Fire Management Officers conducted a mapping exercise to refine AMR boundaries, at which time a single AMR was assigned to each area of the Forest having burnable vegetation. This exercise considered Management Area prescription, proximity to values at risk, predominant wind patterns, and other factors to arrive at appropriate AMR. These areas will be further refined in the Fire Management Plan. The refined AMR map was presented to the Forest Leadership Team and the County Steering Committee as part of the process. This map can be found in Plan Appendix D and is on file at the Bighorn Forest Supervisor's Office.

The parameters under which each AMR is managed will be outlined in the FMP (Fire Management Plan). When the FMP has been completed and approved, all ignitions will receive the full extent of management options available, depending upon resource management objectives presented in the FMP. These options range from monitoring with minimal on-the-ground actions to intense suppression actions on all or portions of the fire perimeter. The appropriate management response is developed from analysis of the local situation, values to be protected, management objectives, external concerns, and land use. The Forest Plan is a decision document, where the Fire Management Plan is an implementation document. Note that current direction allows for a change in strategy from a wildland fire use strategy to a more restrictive strategy such as confinement. For example, assume the Forest Plan assigns an AMR of prescription control to a specific area, however, during subsequent development of the FMP, it may be determined that direct control is a more suitable AMR due to the small size of the area and/or the proximity of values at risk. One may not deviate from a containment strategy, such as direct control, to a fire use strategy, such as prescription control.

Acres Burned by Wildfire

It is very difficult to predict the number of acres that will be burned by wildfire in future years. Conditions that dictate the severity of fire seasons tend to vary significantly year to year.

Weather, which is the primary influence on availability of fuels for ignition, is very difficult to predict with any degree of reliability more than a few days into the future. Research suggests that large stand-replacing fires are more likely to occur because of weather conditions than fuel accumulations. Most large fires occur in years with elevated weather variable values and fires in those years account for >99% of the area burned {Bessie and Johnson, 1995}. Prediction of major influences, such as the occurrence of drought, is improving, but is still not very reliable. For these reasons, the best method for predicting the number of acres that will burn in the future is to base the prediction on historical fire occurrence.

In an effort to predict the number of acres that will be burned in the future, in a decade, the fire probability analysis program PROBACRE {Wiitala 1999} was utilized. This program assesses the risk of catastrophic consequences from a single wildfire or series of wildfire events. PROBACRE calculates the probability of a major single event, or multiple fire events, and the long-term probability that a combination of fire events, both large and small, would result in a total burned area in excess of a particular number (user-specified). The probabilities are calculated from historic fire information for annual frequency of fires by size class.

The PROBACRE analysis period was 10 years. The probability analysis was completed for the Bighorn Mountain Face, Bighorn Montane Area Above 7000 Feet, Cloud Peak Wilderness, and for the Bighorn National Forest, as a whole, using historical fire records from 1970 through 2004.

FMZ1 Bighorn Mountain Face As indicated on the following table for the Bighorn Mountain Face, there is a 22% chance that there will be at least one fire during the planning period that will exceed 9999 acres in size. There is a 26% probability that wildfires will cumulatively burn more than 10,000 acres during the planning period.

Table B-13. FMZ1 (Bighorn Mountain Face) fire size and frequency probability.

SIZE	FIRE FREQUENCY		PROBABILITY OF NUMBER OF FIRES PER PERIOD					
CLASS	ANNUAL	PERIOD	NONE	1	2	3	4	>4
0	4.230	42.30	0.000000	0.000000	0.000000	0.000000	0.000000	1.0000
10	2.110	21.10	0.000000	0.000000	0.000000	0.000000	0.000006	1.0000
99	0.490	4.90	0.007447	0.036488	0.089396	0.146014	0.178867	0.5418
299	0.170	1.70	0.182684	0.310562	0.263978	0.149587	0.063575	0.0296
999	0.110	1.10	0.332871	0.366158	0.201387	0.073842	0.020307	0.0054
9999	0.030	0.30	0.740818	0.222245	0.033337	0.003334	0.000250	0.0000
PROBABILITY OF EXCEEDING 10-ACRE THRESHOLD IN 10 YEARS IS1.00000								
PROBABILITY OF EXCEEDING 100-ACRE THRESHOLD IN 10 YEARS IS 1.00000								
PROBABILITY OF EXCEEDING 500-ACRE THRESHOLD IN 10 YEARS IS 0.99357								
PROBABILITY OF EXCEEDING 1,000-ACRE THRESHOLD IN 10 YEARS IS 0.92172								

SIZE	FIRE FREQUENCY		PROBABILITY OF NUMBER OF FIRES PER PERIOD					
CLASS	ANNUAL	PERIOD	NONE	1	2	3	4	>4
PROBABILITY OF EXCEEDING 2,500-ACRE THRESHOLD IN 10 YEARS IS 0.55173								
PROBABILITY OF EXCEEDING 5,000-ACRE THRESHOLD IN 10 YEARS IS 0.27548								
PROBABILITY OF EXCEEDING 10,000-ACRE THRESHOLD IN 10 YEARS IS 0.25782								
PROBABILITY OF EXCEEDING 15,000-ACRE THRESHOLD IN 10 YEARS IS 0.04046								
PROBABILITY OF EXCEEDING 25,000-ACRE THRESHOLD IN 10 YEARS IS 0.00256								
PROBABILITY OF EXCEEDING 50,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								

FMZ2 Bighorn Montane Area Over 7000 Feet As indicated in the following table for the Bighorn Montane Area, there is a 22% chance that there will be at least 3 fires during the planning period that will exceed 999 acres in size. There is a 19% probability that wildfires will cumulatively burn more than 5,000 acres during the planning period.

Table B-14. FMZ2 (Bighorn Montane Area > 7000 feet) fire size and frequency probability.

SIZE	FIRE FREQUENCY		PROBABILITY OF NUMBER OF FIRES PER PERIOD					
CLASS	ANNUAL	PERIOD	NONE	1	2	3	4	>4
0	9.26	92.60	0.000000	0.000000	0.000000	0.000000	0.000000	1.0000
10	2.09	20.90	0.000000	0.000000	0.000000	0.000001	0.000017	1.0000
99	0.17	1.70	0.182684	0.310562	0.263978	0.149587	0.063575	0.0296
299	0.06	0.60	0.548812	0.329287	0.098786	0.019757	0.002964	0.0004
999	0.29	2.90	0.055023	0.159567	0.231373	0.223660	0.162154	0.1682
9999	0.000	0.000	1.000000	0.000000	0.000000	0.000000	0.000000	0.0000
PROBABILITY OF EXCEEDING 10-ACRE THRESHOLD IN 10 YEARS IS 1.00000								
PROBABILITY OF EXCEEDING 100-ACRE THRESHOLD IN 10 YEARS IS 1.00000								
PROBABILITY OF EXCEEDING 500-ACRE THRESHOLD IN 10 YEARS IS 0.98105								
PROBABILITY OF EXCEEDING 1,000-ACRE THRESHOLD IN 10 YEARS IS 0.95091								
PROBABILITY OF EXCEEDING 2,500-ACRE THRESHOLD IN 10 YEARS IS 0.70597								
PROBABILITY OF EXCEEDING 5,000-ACRE THRESHOLD IN 10 YEARS IS 0.18506								
PROBABILITY OF EXCEEDING 10,000-ACRE THRESHOLD IN 10 YEARS IS 0.00056								
PROBABILITY OF EXCEEDING 15,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 25,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 50,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								

FMZ3 Bighorn Cloud Peak Wilderness As indicated in the following table for the Cloud Peak Wilderness, there is a 33 % chance that there will be at least 1 fire during the planning period that will exceed 10 acres in size. There is a 43% probability that wildfires will cumulatively burn more than 10 acres during the planning period.

Table B-15. FMZ3 (Bighorn Cloud Peak Wilderness) fire size and frequency probability.

SIZE	FIRE FREQUENCY		PROBABILITY OF NUMBER OF FIRES PER PERIOD					
CLASS	ANNUAL	PERIOD	NONE	1	2	3	4	>4
0	0.29	2.90	0.055023	0.159567	0.231373	0.223660	0.162154	0.1682
10	0.06	0.60	0.548812	0.329287	0.098786	0.019757	0.002964	0.0004
99	0.000	0.000	1.000000	0.000000	0.000000	0.000000	0.000000	0.0000
299	0.000	0.000	1.000000	0.000000	0.000000	0.000000	0.000000	-.0000
999	0.000	0.000	1.000000	0.000000	0.000000	0.000000	0.000000	-.0000
9999	0.000	0.000	1.000000	0.000000	0.000000	0.000000	0.000000	-.0000
PROBABILITY OF EXCEEDING 10-ACRE THRESHOLD IN 10 YEARS IS 0.43319								
PROBABILITY OF EXCEEDING 100-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 500-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 1,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 2,500-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 5,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 10,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 15,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 25,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								
PROBABILITY OF EXCEEDING 50,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								

Forest Total for All Bighorn FMZ'S As indicated in the following table for all Bighorn FMZ's, there is a 22% chance that there will be at least 1 fire during the planning period that will exceed 9999 acres in size. There is an 18% probability that wildfires will cumulatively burn more than 15,000 acres during the planning period.

Table B-16. Fire size and frequency probability for all Bighorn FMZs.

SIZE	FIRE FREQUENCY		PROBABILITY OF NUMBER OF FIRES PER PERIOD					
CLASS	ANNUAL	PERIOD	NONE	1	2	3	4	>4
0	13.78	137.80	0.000000	0.000000	0.000000	0.000000	0.000000	1.0000
10	4.260	42.600	0.000000	0.000000	0.000000	0.000000	0.000000	1.0000
99	0.660	6.60	0.001360	0.008978	0.029629	0.065183	0.107553	0.7873
299	0.23	2.30	0.100259	0.230595	0.265185	0.203308	0.116902	0.0838
999	0.40	4.00	0.018316	0.073263	0.146525	0.195367	0.195367	0.3712
9999	0.03	0.30	0.740818	0.222245	0.033337	0.003334	0.000250	0.0000
PROBABILITY OF EXCEEDING 10-ACRE THRESHOLD IN 10 YEARS IS 1.00000								
PROBABILITY OF EXCEEDING 100-ACRE THRESHOLD IN 10 YEARS IS 1.00000								
PROBABILITY OF EXCEEDING 500-ACRE THRESHOLD IN 10 YEARS IS 1.00000								
PROBABILITY OF EXCEEDING 1,000-ACRE THRESHOLD IN 10 YEARS IS 0.99967								
PROBABILITY OF EXCEEDING 2,500-ACRE THRESHOLD IN 10 YEARS IS 0.97561								
PROBABILITY OF EXCEEDING 5,000-ACRE THRESHOLD IN 10 YEARS IS 0.73540								
PROBABILITY OF EXCEEDING 10,000-ACRE THRESHOLD IN 10 YEARS IS 0.28360								
PROBABILITY OF EXCEEDING 15,000-ACRE THRESHOLD IN 10 YEARS IS 0.17874								
PROBABILITY OF EXCEEDING 25,000-ACRE THRESHOLD IN 10 YEARS IS 0.02356								
PROBABILITY OF EXCEEDING 50,000-ACRE THRESHOLD IN 10 YEARS IS 0.00000								

Analysis of Rangeland Capability and Suitability for Livestock Grazing

Range Analysis

Requirements to perform analysis of rangeland suitability are found in NFMA at 16 U.S.C. 1604(g)(2)(A) and 36 CFR219.20. FSM 1905 contains a definition of "Lands Suitable for Grazing and Browsing" as lands with vegetation that can be used by grazing animals, both domestic and wild herbivores, without damage to the soil and water values.

The Code of Federal Regulations (CFR) contains several provisions dealing with rangeland capability and suitability. Specifically, 36 CFR 219.3 provides definitions as follows:

Capability: The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends on current conditions and site conditions such as climate, slope, landform, soils, and geology, as well as the application of management practices, such as silviculture, or protection from fire, insects and disease.

Suitability: The appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses foregone. A unit of land may be suitable for a variety of individual or combined management practices.

The 36 CFR 219.20 contains the following direction about grazing resources in Forest planning:

- In Forest planning, suitability and potential capability of NFS lands for producing forage for grazing animals and for providing habitat for indicator species shall be determined as provided in paragraphs (a) and (b) of this section. Lands so identified shall be managed in accordance with direction established in Forest plans.
- (a) Lands suitable for grazing and browsing shall be identified and their condition and trend shall be determined. The present and potential supply of forage for livestock, wild and free roaming horses and burros, and the capability of these lands to produce suitable food and cover for selected wildlife species shall be estimated. The use of forage by grazing and browsing animals will be estimated. Lands in less than satisfactory condition shall be identified and appropriate action planned for their restoration.
- (b) Alternative range management prescriptions shall consider grazing systems and the facilities necessary to implement them; land treatment and vegetation manipulation practices; evaluation of past problems; possible conflict or beneficial interactions among livestock, wild free-roaming horses and burros and wild animal populations, and methods of regulating these; direction for rehabilitation of ranges in unsatisfactory condition; and comparative cost efficiency of the prescriptions.

The process used for determining rangeland capability and suitability is outlined in the

Region 2 desk guide "Rangeland Suitability for Livestock Grazing at the Forest Plan Level and Standards for NEPA display.

Capability and suitability were determined through the use of Geographic Information Systems (GIS) technology. Based on the nature of GIS, acreage for each feature considered not capable or unsuitable is systematically eliminated from the suitable base one layer at a time. Overlapping features are subtracted only once to prevent double counting of acres. As an example, on a heavily forested developed recreation site, if the site is entirely forested, all the acres are eliminated at the dense forest canopy layer, once subtracted those same acres are no longer available to be subtracted at subsequent levels (i.e. under the developed recreation site layer). This explains why the acreage deducted in the following tables for a specific feature may be somewhat less than the total acres for that feature.

Rangeland Capability Capable rangelands are those lands that are accessible to livestock, produce forage, or have inherent forage producing capability, and can be grazed on a sustained basis. To determine acres capable of supporting livestock, land was systematically eliminated from the gross National Forest System (NFS) lands as shown in the following table. Rangeland capability does not vary by alternative.

Table B-17. Acres of land determined as capable for livestock use.

Classification/Description	Acres Deducted	Running Totals
Net National Forest System Acres	-------	1,105,017
Deductions for other than capable acres	-------	1,105,017
Soil types that are dominated by a large percentage of rock outcrop	340,944	764,073
Lands that are not capable of producing 200 pounds of forage per acre	63,347	700,727
Lakes, reservoirs, ponds, and marshes	10,564	690,163
Major rivers within the Bighorn National Forest proclaimed boundary	0	690,163
Perennial streams	1,178	688,985
Roads and highways	3,788	685,197
Slopes greater than 60% (not capable sheep or cattle)	22,022	663,175
Slopes between 41%-60% (not capable cattle)	50,621	
Total capable for sheep grazing	441,842	663,175
Total capable for cattle grazing	492,463	612,554

Rangeland suitability Suitability is the appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses foregone. A unit of

land may be suitable for a variety of individual or combined management practices. The suitability analysis is presented in two parts: current suitability and suitability by Forest Plan alternative. To determine acres present environmentally suitable for livestock grazing, land was systematically eliminated from the net National Forest System Lands using GIS technology as shown in the following tables.

Table B-19. Acres of land determined as suitable for livestock use.

Classification/Description	Cattle		Sheep	
	Acres Deducted	Running Totals	Acres Deducted	Running Totals
Net National Forest System Acres	------	1,105,017	------	1,105,017
Deductions for other than capable acres	492,463	612,554	441,842	663,175
Deductions for other than suitable acres	0	612,554	0	663,175
-Existing canopy cover >70%	474678.7	137,875	474678.7	188,496
-Shell Canyon and Bull Elk Park RNA's that exclude livestock	175.1987	137,700	175.1987	188,321
Developed recreation sites	145.08	137,555	145.08	188,176
-Range exclosures	2067.718	135,487	2067.718	186,108
-Forage not available due to right-of-way fences & other limitations	872.6389	134,615	872.6389	185,236
-Current grazing closures	0	134,615	0	185,236
-Threatened, Endangered, and Sensitive Species Closures	0	134,615	0	185,236
-Other incompatibilities	0	134,615	0	185,236
-Economical Feasibility	0	134,615	0	185,236
Total suitable acres (cattle)		134,615		
Total suitable acres (sheep)				185,235

Table B-18. Acres determined at the forest plan level as suitable for livestock use.

Classification/Description	Acres Suitable
Total Suitable Determination Acres for Cattle grazing	134,615
Total Suitable Determination Acres for Sheep grazing	185,235

There was a wide discrepancy in acres of suitable rangeland described between draft and final. Differences are largely a result of two items: 1) the GIS method of calculating slope, and 2) the crown coverage information. Smaller differences were a result of 1) review and revision of criteria, and 2) refinement and update of data used.

The slope difference is based on using different methods to calculate the slope class. Slope calculations area values were derived from a 30 meter DEM. The prior analysis used the slope value for each cell to determine if it was between 40 to 60% slope. The current analysis classified each cell into either 0 - 40%, 40 - 60% or 60+% slope. The value for each cell was then determined by calculating the modal class for the adjacent cells within a 3-cell or 90 meter radius of the target cell. Using this method removes small variations in the landscape and gives a better representation of the landform in an area.

Differences in the vegetation/canopy deductions appear to be because the previous suitability analysis included areas as capable that should have been removed from the capable area, based on vegetation criteria.

There are several points to consider when interpreting and 'using' the information derived from this calculation:

- Range suitability is a required calculation under the 1982 planning regulations, 36 CFR 219.
- Much of the analysis is done at the 1.1 million acre scale, using previously acquired, remotely sensed data. While a certain percentage of data is ground-truthed, it still is coarse, approximate information. Therefore, the information derived from it should be considered coarse, approximate information.
- The number of suited acres is not used for grazing decisions at the LRMP level. Actual stocking rates, seasons of use, rotations, etc. are derived from on the ground, individual allotment planning decisions. They are based on actual conditions (applied management), and on past knowledge, trends, and conditions.

For these reasons, it would be inappropriate to develop stocking rates solely from this information.

Suitability by Alternative: Livestock grazing has not been identified as an inappropriate activity in any management prescriptions, although it may be limited in Research Natural Areas when establishment records are developed. Acres suitable for grazing do not vary by alternative.

No alternatives under consideration propose to permanently close any allotments to domestic livestock grazing.

Economic Analysis: Forest-wide standards and guidelines for grazing identify desired resource conditions across all alternatives. To achieve these desired resource conditions, specific grazing systems, stocking rates, needed structural, non structural range improvements and coordination with other resources are developed at the allotment management planning level based on the site specific conditions. Presently there are numerous grazing systems being use on the forest, including but not limited to, multi pasture rotational, deferred rotational, rest rotational, alternate year, once over lightly, high intensity, short duration and to a limited degree continuous.

Livestock grazing was not identified as a major revision topic in this Forest Plan.

Differences between alternatives are primarily based on the differences in standards and guidelines between management prescriptions, and the mix of acreages of prescriptions between alternatives, rather than how those livestock are to be managed. Therefore, a detailed examination of every available grazing system for each of the alternatives was not warranted. For purposes of analysis, the financial and economic consequences of two grazing prescriptions are compared in Table B-21.

Prescription A: This prescription is representative of lands managed under active grazing. This prescription looks at Forest-wide standards and guidelines and management area direction needed meet resource goals and objectives. Grazing systems are developed within this direction at the site-specific level. Range improvements are maintained at grazing permittees expense. Existing improvements that have reached the end of their physical life span would be reconstructed as needed or removed. New improvements are approved on a case-by-case basis. Forest-wide standards and guidelines are designed to improved unsatisfactory range condition. Areas in unsatisfactory condition become satisfactory through mitigation identified during site-specific analysis. Noxious weed management would continue at present levels. Vegetation treatment with prescribed fire would be conducted primarily for wildlife habitat improvement and fuels reduction. In general, forest-wide stocking is expected to remain fairly constant at or near 2.5 acres/head month. Vacant allotments remain in vacant status until site-specific analysis can be completed.

Prescription B. Currently grazed lands would be managed without grazing. Current grazing permits would be cancelled or not reissued at end of current term. All existing range improvements not needed for other resources or needed to prevent livestock trespass from adjacent lands would be removed. Noxious weed management would continue at present levels.

Table B-19. Financial and economic comparison of grazing prescriptions.

Grazing Prescriptions	Average Profile for Lands Managed for Active Grazing	Average Profile for Lands Currently Grazed, but No Longer Managed for Grazing
Estimated Grazing (Annual Average, 2001-2010)		
Sheep: Head Months per Acre	.32 BNF	0
Animal Unit Months per Acre	.22 BNF	0
Cattle: Head Months per Acre	.109 BNF	0
Animal Unit Months per Acre	.425 BNF	0
Financial Analysis (taxpayer/agency perspective)		
Revenues per Acre per Year		
Sheep	$0.47	--
Cattle	$0.25	$0.00
Costs per Acre per Year		

Grazing Prescriptions	Average Profile for Lands Managed for Active Grazing	Average Profile for Lands Currently Grazed, but No Longer Managed for Grazing
Sheep	$0.47	--
Cattle	$1.02	$0.27
Net Revenue per Acre per Year		
Sheep	$0.00	---
Cattle	-$0.77	-$0.27
Present Net Value Per Acre in Decade 1		
Sheep	-$3.34	---
Cattle	-$6.82	-$2.31
Economic Analysis (society perspective)		
Benefits per Acre per Year		
Sheep	$1.11	--
Cattle	$2.40	$0.00
Costs per Acre per Year		
Sheep	$2.23	--
Cattle	$3.11	$0.27
Net Benefit per Acre per Year		
Sheep	-$1.12	--
Cattle	-$0.71	-$0.27
Present Net Value per Acre in Decade 1		
Sheep	-$10.15	--
Cattle	-$6.98	-$2.31

Source: Data derived from the White River National Forest unless otherwise noted

The economic analysis was completed from two perspectives: Financial efficiency and cost effectiveness. Financial considerations include only those revenues received by and costs incurred by the Forest Service. Economics considerations include the benefits and costs of grazing to all of society. Economically, actively grazed lands benefit society by providing food and fiber, and employment. These calculations do not include benefit or costs for which monetary values are unavailable.

Based on the information discussed above, certain rangelands were determined to be suitable for livestock grazing. The results of this determination are summarized in the following tables. Not all of these lands will be stocked, but all are considered available for grazing.

Table B-20. Acres suitable for cattle grazing by alternative.

	Alt A	Alt. B	Alt. C	Alt. DDEIS	Alt. DFEIS	Alt. E
Acres presently suitable for cattle grazing	134,615	134,615	134,615	259,093	134,615	134,615
Management area prescriptions Excluding Grazing	0	0	0	0	0	0
Acres proposed for full or partial closure in this alternative	0	0	0	0	0	0
Total Environmentally Suitable Acres (cattle) for this alternative	134,615	134,615	134,615	259,093	134,615	134,615
Economically unsuitable for Cattle	0	0	0	0	0	0
Suitable Acres for Cattle Grazing	134,615	134,615	134,615	259,093	134,615	134,615

Table B-21. Acres suitable for sheep grazing by alternative.

	Alt A	Alt. B	Alt. C	Alt. DDEIS	Alt. DFEIS	Alt. E
Acres presently suitable for cattle grazing	134,615	134,615	134,615	259,093	134,615	134,615
Management area Prescriptions Excluding Grazing	0	0	0	0	0	0
Acres proposed for full or partial closure in this alternative	0	0	0	0	0	0
Total Environmentally Suitable Acres (sheep) for this alternative	185,235	185,235	185,235	268,230	185,235	185,235
Economically unsuitable for Sheep	0	0	0	0	0	0
Suitable Acres for Sheep Grazing	185,235	185,235	185,235	268,230	185,235	185,235

Alternative Uses Foregone

An analysis of alternative uses forgone is required in the planning document based on how each of the alternatives deals with the findings of suitability. This analysis is expressed in terms of the effects of continuing to permit livestock grazing of existing lands, or to permit livestock grazing of any lands not currently authorized under permit, and the potential effects that permitting grazing would have on the elimination or restriction of other activities or resource values.

For example, a decision to potentially allow livestock use of a given area means that forest visitors desiring to experience a wildland free of human influences would not be able to do so on the given area of land. Conversely, decisions to eliminate livestock grazing from any lands

where it is currently authorized, or potentially could be authorized, may have effects on values such as local community stability, rural lifestyle, open space protection, and so forth.

The analysis of uses forgone must detail the effects of the alternative actions with regard to the tradeoffs associated with decisions regarding permitted grazing or no grazing to the extent that those decisions preclude or restrict other resource uses and values.

There are some areas of land within the Forest that are not planned by a specific alternative to have permitted livestock grazing for various reasons. Areas such as developed campgrounds and administrative sites (except for administrative pack and saddle stock pastures) are not generally considered to be suitable for livestock grazing. There are also areas on the Forest where no livestock grazing allotments exist due to various administrative reasons such as conflicts with recreation, access limitations, etc. These areas are common to all action alternatives. Under the No Grazing alternative, all acres are considered to be unsuitable for livestock grazing during this planning cycle.

The economic analysis was completed from two perspectives: Financial efficiency and cost effectiveness. Financial considerations include only those revenues received by and costs incurred by the Forest Service. Economics considerations include the benefits and costs of grazing to all of society. Economically, actively grazed lands benefit society by providing food and fiber, and employment. These calculations do not include benefit or costs for which monetary values are unavailable.

Rangeland Capability Analysis

Rangeland Capability Analysis is described in the "Region II Desk Guide for Forest Planning". The documentation of the process begins on page G.7 and the chapter originally used was dated July 12, 2001. The June 10, 2004 version was used in review between draft and final. Major headings in this document represent the steps defined above.

GIS was used to identify areas that met the following criteria. The best available data was used in making the determinations.

1. Begin with all lands within the project area that are National Forest System (NFS) lands.

The Land Status staff, located at the regional office, provided the land status data. They use a mix of public records and land survey data to maintain the forest ownership layer.

2. Subtract soil types that are dominated by a large percentage of rock outcrop and rubbleland, loose granitic or highly erosive soils, very wet and boggy soils, and sites with high mass movement risk. Optional - to identify erosive areas, a geologic layer to identify active landslides, slumps, etc. may be used.

Soil Survey indicated that soils dominated by a large percentage of

-rock outcrop and rubbleland in map units 10, 31, 32, 33, 34, 35, 36, 37. We recognize that the soil survey lists relative percentages of rock outcrop and rubbleland in each map unit, and

we considered using only that percentage of each polygon as not capable. We chose not to do so because 1) this is not what the regional guide suggested, and 2) there was no way to know where spatially this percentage would reside within that polygon, a critical piece of information relative to subsequent analysis.

-loose granitic: The soil survey does not use this specific descriptor in either the narrative or the summary. For this exercise we assumed that "loose granitic" soils are addressed in the "rock outcrop and rubbleland" soils above.

-highly erosive soils: Soil survey lists series 24, 30, and 43 as having moderate to severe water erosion. It states that on severe soils (Leavitt, Waybe, Tongue River) "the hazard of erosion… requires careful grazing management". It does not suggest that grazing should not occur, so no units were pulled out due to water erosion. Site-specific problem areas can be addressed, if present, in allotment planning.

-very wet and boggy soils: Soil survey summary lists only soil unit #16 as having wetness limitations due to "frequent flooding and poor drainage. Annual production is shown as 3000 – 3500 lb/acre. Since grazing could likely occur in these areas without accelerating erosion or other undesirable effects, these soils should not be considered "not capable or suitable" in this stage of the process. They may be identified, and problem areas can be addressed, in site specific planning.

-sites with high mass movement risk. Soil survey summary lists Soil Units 17, 29, and 30 as being characterized by some degree of "mass movement". Soil association descriptions do not suggest that grazing should not occur or would create accelerated mass movement in these areas. Since grazing could likely occur in these areas without accelerating mass movement, these soils should not be considered "not capable or suitable" in this stage of the process. They may be identified, and problem areas can be addressed, in site specific planning.

A geologic layer identifying active landslides, slumps, etc. was not used to identify erosive areas. No such data is currently available, areas are known only anecdotally and they are few, and these can be more effectively identified in site specific planning. The landslide layer we have is for landslide hazard, and not the actual locations of slides.

3. Subtract soil types that are not inherently capable of producing more than 200 pounds of forage/acre within their Potential Natural Community (such as badland outcrops, nutrient-poor soils, shallow soils, or alkali salt flats). If a figure other than the "200 pounds per acre" is used, document the rationale.

Soil survey indicates that associations 13 and 37 produces less than 200 lb/acres forage. These were considered not capable. We recognized that CVU data could be used to identify areas that produced less than 200 lb/acre forage, but we felt double counting areas to be a risk. We chose to 1) follow process outlined by the regional guide, and 2) use soil survey data.

4. Subtract areas that consist of lakes, reservoirs, or ponds, e.g. the area covered by water at the high water mark.

Areas that consist of lakes, reservoirs, ponds, and marshes were eliminated in this step.

5. Buffer major rivers (Colorado or North Platte, for example) by the actual width (averaged for individual reaches if need be) and subtract.

No major rivers exist within the proclaimed boundary for the Bighorn National Forest. The Big Horn River on the west side of the Forest is an example of a major river.

6. Buffer perennial streams by the actual width of the water surface at the mean high water mark, or use an average width of 3 feet on either side of center line and subtract. The 6-foot width for perennial streams represents an average width for a stream's water surface and can be used as a Unit-wide average for purposes of modeling.

We used the following variable width buffer, based on stream order.

Table B-22. Range analysis stream buffer width by stream order.

Stream Order	Buffer Width
1	1 foot
2	2 feet
3	3 feet
4	5 feet
5	10 feet
6	10 feet

7. Buffer National Forest system roads by 8 feet on either side of center line and subtract. The 16-foot width for roads represents an average width for a road's surface and can be used as a Unit-wide average for purposes of modeling. The road surface is not considered to be capable unless the road surface has been obliterated and re-vegetated in which case, the road surface will remain within the capable land base.

For this step, only the actual road surface area is deducted. A variable width buffer was used based on road objective maintenance level. The widths are as indicated in the following table.

Table B-23. Range analysis road buffer width by objective maintenance level.

Objective Maintenance Level	Buffer Width
1	8 feet
2	8 feet
3	15 feet
4	20 feet
5	20 feet
Hwy 14, 14a, 16	30 feet

These buffer widths for both roads and streams are the same as used in the tentatively suited timber analysis.

8. Subtract slopes meeting the following criteria:

a. Subtract slopes greater than 60% (not capable for either sheep or cattle). Keep track of capable acres for cattle and sheep separately (may also need to track separately for other kinds and classes of livestock such as bison, if the need presents). The 60% figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

b. From the above (a) capability calculations, subtract slopes greater than 40% (slopes of 41-60% are capable for sheep but not normally for cattle). The 40% figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

Slopes in excess of 40% are considered not capable of supporting cattle. Slopes in excess of 60% are considered not capable of supporting sheep or cattle.

No rationale has been identified to justify a deviation from the suggested slope criteria. Areas where slope is deemed to reduce forage availability beyond that identified above can be identified in site specific planning.

Areas less than one acre in size (four or fewer 30-meter grid cells) were removed.

9. Optional: subtract areas that lack available water, or lack the potential to develop water, within approximately 3 miles of the center of the polygon for Grasslands or one mile in mountainous rangelands. This figure can be modified for each specific Forest or Geographic area to fit with local situations (with documented rationale).

While there may be areas on the BNF that lack available water, few areas lack potential to develop water. Water is currently being conveyed great distances through stock

pipelines, and other technologies are being developed. For these reasons, the option of subtracting areas that could conceivably lack water was not done. Such areas may be identified in site specific planning.

10. The remaining area is **Capable Rangeland.** The capable rangeland may be displayed as two separate map displays and acreage tables: one map/acreage table set displays capable polygons/acreage for cattle; and, a second set displays capable polygons/acreage for sheep if appropriate. Other displays may be used for other kinds of animals as needed.

Rangeland Suitability Analysis

The definition of suitability was found at 36 CFR 219.3 and is found in FSM 1905 as follows:

Suitability: The appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses forgone. A unit of land may be suitable for a variety of individual or combined management practices. Rangeland suitability may vary by alternative being considered in the Land Management Planning process. For this reason, suitability will need to be determined by alternative or grouping of similar alternatives.

Required Data for Determination of Rangeland Suitability

• Capability Evaluation as detailed above. Areas determined to be other than capable, are by default, also not considered to be suitable.

• Percent tree or unpalatable shrub canopy cover - from RMRIS database or from Common Vegetation Unit or IRI

• Management Area Prescription/Allocation proposed for each alternative.

• Areas closed to livestock grazing as proposed for each alternative.

• Fenced Recreation Areas and/or Sites where livestock is to be excluded, as proposed for each alternative.

• Fenced cultural resource or other special management areas where livestock is excluded or is proposed to be excluded from livestock grazing, by alternative.

• Administrative Sites where livestock grazing is, or is proposed to be, excluded during the life of the plan (except administrative pack and saddle pastures which would be considered to be suitable)

• Special Use Sites where livestock grazing is determined to be incompatible with the purpose of the special use (summer homes, electronic sites, etc.). This determination may vary by alternative.

• Permanent exclosures fenced so as to exclude livestock use during the life of the plan.

• Road rights of way/easements (not including the actual road bed as that is covered in the capability analysis) where such right of way is or is proposed to be fenced to exclude livestock grazing. Include actual or estimated area fenced (from CFFs).

• Railroads rights of way/easements where such right of way is or is proposed to be fenced to exclude livestock grazing. Include actual area fenced or estimated (from CFFs).

• Research Natural Areas where decisions have been made or are proposed in the alternative, to exclude livestock.

• Research facilities, municipal watersheds, or other special purpose areas where decisions have been made, or are proposed in the alternative, to exclude livestock.

• Threatened or Endangered Species habitat permanently excluded from livestock grazing, or proposed in the alternative for exclusion through the life of the plan. Include Threatened or Endangered Species habitat where determinations have been made that livestock grazing is incompatible with the viability of the habitat or species.

• Minerals production areas (mills, mines, settling ponds, etc.) where livestock grazing is incompatible with the minerals activity for safety or other reasons.

• Conduct economic efficiency analysis by alternative to determine cost efficiency (36 CFR 219.3, definition of suitability and 36 CFR 219.20(b)). Determine if areas that are not economically efficient (i.e. discounted costs exceed discounted benefits) under circumstances expected to prevail during the life of the plan should be classified as other than suitable. Present net value calculated over decade one is a reasonable approximation of expected plan life. NFMA does not require present net value to be positive for rangelands to be suitable. RPA values, as updated by the WO range staff must be used for benefit estimation. There are no specific criteria for determining suitability based on economic efficiency. This analysis is completed so that the decision maker is better informed and understands the economic trade-offs prior to making the decision.

• Conduct financial efficiency analysis by alternative to reveal the costs and revenues to agency and Federal taxpayers. Present net value calculated over decade one is a reasonable approximation of expected plan life. There is no requirement for present net value to be positive, especially since law and executive order establish grazing fees. Current grazing fees must be used for revenue estimation. Financial efficiency provides an analytical complement to economic efficiency. This analysis is completed so that the decision maker is better informed and understands the financial trade-offs prior to making the decision.

Process for Determination of Rangeland Suitability.

To determine rangeland suitability (36 CFR 219.3, definition of suitability), perform the following as a separate GIS analysis for each alternative or group of similar alternatives.

Rangeland Suitability Analysis is described in the "Region II Desk Guide for Forest Planning". The documentation of the process begins on page G.10 and the chapter originally used is dated February 13, 2002. The June 10, 2004 version was used in review

between draft and final. Major headings in this document represent the steps defined above.

1. Subtract areas determined to be other than capable as determined in the capability evaluation above.

> The process begins where Rangeland Capability stops. Data is currently stored at: J:\fsfiles\office\bhgis\revision_eis\range\suited_analysis_2005\r_capable. The buffers have remained consistent throughout the process.

2. Subtract areas that currently have an overstory of tree canopy cover and/or unpalatable shrub canopy cover greater than 70% (note: local exceptions to the 70% figure may be determined to be appropriate for specific situations, such as Aspen communities, provided that the rationale is documented).

a. Transitory range will normally be considered as a special short term instance where suitability occurs because of the removal of the overstory vegetation (as by fire or harvest). However, since the long term site potential is normally a moderate to dense canopy with little understory production, and since these areas are normally dedicated to timber (and other resource) production, these areas are generally considered to be suitable for grazing only for the lifespan of the time that it takes for the canopy to once again close back to 60% or greater, and only if the costs or viability of adequately mitigating effects relative to livestock grazing on forest vegetation regeneration are acceptable.

b. Use harvest maps and records to determine if specific areas currently meet the suitable criteria and if they are expected to remain within that criteria for the life of the plan. If so, they are determined to be suitable. If the transitory site will become other than suitable during the life of the plan, either portray it as being other than suitable, or show it as being suitable only for the estimated time that it will continue to meet suitability definitions.

c. Optional: Certain vegetative types (such as some Aspen communities) may be suitable for a given type of livestock in certain geographic areas and not in other areas. If appropriate, these vegetative communities may be subtracted out of the suitable acres as needed. Document the rationale for the decision.

> The Common Vegetation Unit coverage has information on the cover types and canopy cover throughout the Bighorn National Forest. Only those stands where the canopy cover of grasses and forbs exceeds 30 percent are classified as capable of supporting livestock management.
>
> The Regional Guide recommendation above (forested vegetation with a canopy cover of grasses and forbs that exceeds 30 percent as suitable) was used as a "coarse-filter" representation of suitable range. We recognize that these polygons may have inclusions of areas with both more and less forage. We also recognize that these polygons include aspen stands where livestock grazing can have a detrimental effect on regeneration;

such detrimental effects are far from consistent through out all aspen stands, however, and often can be controlled through management. Areas where livestock use results in detrimental effects to aspen can be identified and addressed in site specific planning.

We did not include transitory range as suitable (available because of removal of the overstory vegetation by fire or harvest). Since these areas are normally dedicated to timber (and other resource) production, the long-term site potential is normally a moderate to dense canopy with little understory production. Forage in these areas is not included in long term grazing permit allocations because it is available for grazing only for the time that it takes for the canopy to once again close back to 60% or greater. Such an allocation would not provide any degree of stability to the producer. In addition, projections for future timber harvest are not available spatially with a high degree of reliability, a critical piece of information relative to subsequent analysis.

3. Subtract areas that have a proposed management area prescription allocation that does not allow for livestock grazing (e.g., certain Research Natural Areas, experimental forests, municipal watersheds). Subtract only management area prescriptions that have proposed standards & guidelines that do not allow for livestock grazing management, or where decisions have previously been reached that livestock grazing is incompatible with the planned land management prescription and the proposed alternative would continue that incompatibility finding.

Management Area Prescriptions that would exclude livestock use include Research Natural Areas (RNA's) where the establishment record precludes livestock use. The Forest currently has two RNA's that exclude livestock: Shell Canyon and Bull Elk Park. These two areas were excluded in all alternatives. Suitability for grazing in any new RNA's would be addressed in the establishment record for that RNA. Since proposed RNA's have no establishment record, it was assumed at this point that they be considered suitable.

4. Subtract fenced recreation areas, developed recreation sites, administrative sites (except administrative pack and saddle stock pastures), minerals production sites, fenced cultural resource sites, permanent exclosures, and appropriate special use sites, where livestock use has been determined to be incompatible with the primary land use and/or where the alternative proposes to exclude livestock use.

Range exclosures (finite areas where no livestock grazing is allowed) exist throughout the Bighorn National Forest. Range Conservationists from each of the Ranger Districts provided a list of sites and maps where livestock grazing is excluded, as areas to be removed from the suitable base.

Additionally a number of developed sites were removed from the suitability list. The location of most of these sites is shown as points. To provide an area that is not suitable each point was buffered to create a polygon feature that was then subsequently removed

from the suitable base. The following table shows the features removed as well as the size of polygon used.

Table B-24. Range analysis recreation and administrative site buffer acres.

Feature	Buffered Area
Campgrounds	5 acres
Picnic grounds	5
Resorts	5
Summer homes	5
Ranger and Guard stations	5
Leigh creek dump station	1

Also removed during this step was the approximately 110 acres inside the Medicine Wheel National Historic Landmark.

5. Buffer primary roads (from CFFs or Infra Travel Routes). Primary roads are defined by the actual fenced area, or where a fence is known or proposed to exist but the exact location is unknown, buffer by 100 feet on either side of the center line and subtract.

The roads engineer and range specialist on the Forest Plan ID were consulted as to which roads on the forest are fenced to exclude the presence of cattle. Both specialists concurred that the only fenced roads are US Highways 14, 14A and 16. A 100 foot buffer on either side of each highway was removed from the suitable range base.

6. Buffer secondary/county roads by the actual fenced area, or where a fence is known or proposed to exist, but the exact location is unknown, by 33 feet on either side of the center line and subtract to account for the area that is fenced along secondary/county roads. Only use when the road (or road segment) is fully excluded from livestock grazing on NFS lands. The road surface itself is not considered to be capable. The fenced area alongside the road is capable of growing harvestable forage, but is unsuitable for livestock grazing if decisions have or will be made that livestock grazing is incompatible with other objectives associated with the ROW/easement. Road surfaces are taken out at the capability analysis level and fenced areas along roads are taken out at the suitability analysis level.

No secondary or county roads are fenced for the exclusion of cattle or sheep.

7. Buffer railroads by 100 feet on either side of center line or by the actual fenced area where a fence is known or proposed to exist, and subtract.

No railroads cross the forest thus no area was removed.

8. Subtract areas that are closed to grazing. The reason for past or proposed closure or current lack of livestock grazing activity should be explained (e.g., lack of access, conflicts with wildlife, conflicts with recreation, etc.).

Only that area of the Medicine Wheel HPP that is within the NHL was removed as per step 4.

9. Subtract areas where decisions have been made that specific TES habitats, including habitat for Forest Service sensitive species, need to be excluded from livestock grazing due to an established incompatibility.

No such areas have been identified. Considerations for TES and species of local concern can be identified and made at the site-specific level.

10. Have IDT specialists on the planning team identify any additional areas where conflicts occur between livestock grazing and other resources to the extent that the conflicts cannot be resolved or satisfactorily mitigated, and where the other resource values are proposed in the alternative to take precedence over livestock use. If the planning recommendation is that livestock use in these areas is incompatible, or the conflicts are incapable of being resolved in a satisfactory manner, these lands will be designated as other than suitable for the specific alternative for this planning cycle. Clearly document the reason for the other than suitable determination.

No such areas have been identified. Considerations as described above can be identified and made at the site-specific level.

11. Subtract areas where the IDT has determined that livestock grazing is not economically feasible when considering the costs of complying with applicable laws, regulations and Forest Plan standards. This should not be interpreted as making decisions for a free market but rather should evaluate the costs of mitigations and constraints and management activities that would be needed to ensure compliance.

Distance to water was addressed in capability analysis #9. While water development in some areas may not be economical, our modeling does not address these isolated cases; rather, their limited extent is more appropriately addressed in site specific planning.

12. The remaining area is **Suitable Rangeland** as determined at the Forest Planning level in compliance with Forest Planning Regulation**s.** The suitable rangeland may be displayed as multiple map displays and acreage tables with one map/acreage table display for each alternative.

The final step in this process does not describe any work, but only the result.

Economic Impact Analysis

In order to estimate the economic impacts to the local economy, the Bighorn National Forest (BNF) was divided into western and eastern sides of the Big Horn Mountains. This was done because there are substantial differences in the economic structures of counties on the west and east side of the mountains. Big Horn and Washakie Counties on the west side are traditional economies that are more reliant on mining, agriculture, and manufacturing. Johnson and Sheridan Counties on the east side of the mountains are more service-based economies, with Sheridan also serving as a small regional trade center for the surrounding area. There are also significant economic linkages between counties on either side of the mountains, particularly Sheridan and Johnson. Because of this, the counties on either side of the mountain were combined into one model for the west side and one model for the east side.

Procedures

The economic impacts of the BNF were analyzed using two input-output models. The west side model combined Big Horn and Washakie Counties. The east side model combined Johnson and Sheridan Counties. Both models were based on 2002 IMPLAN data. IMPLAN is a software package for personal computers that uses the latest national input-output tables from the Bureau of Economic Analysis, secondary economic data at the county level from a variety of sources, and proprietary procedures to develop input-output models for every county or group of counties in the nation. The software was originally developed by the U.S. Forest Service and is now maintained by the Minnesota IMPLAN Group, Inc (MIG).

This analysis considered four economic activities associated with the BNF including: 1) Recreation, 2) Timber Production, 3) Livestock Grazing, and 4) BNF Operating Budget. Two thousand and one (2001) was the base year for the analysis. Economic impacts were estimated for the base year and for each alternative developed associated with the Forest Plan. The alternative were evaluated in year 2010 which represented the approximate mid-point of the planning period.

Data and Assumptions

Recreation Data from the National Visitor Use Monitoring Project (NVUM) for the Bighorn National Forest (2002) was used to measure recreational use on the Forest. This data was collected from October 2000 through September 2001. The data indicated a total of nearly 731,000 recreation visits to the BNF annually. Of this total approximately one-third occurred on the west side of the mountains and two-thirds on the east side (RecNumberCalculation5.xls).

In order to estimate the economic impact of recreation it was necessary to first separate local resident visits from other Wyoming residents and nonresident (out-of-state) visits. For purposes of this analysis, Wyoming residents from outside Big Horn, Johnson, Sheridan, and Washakie Counties and out-of-state residents were considered as non-locals. This distinction was necessary since economic impacts are based on new dollars flowing

into the economy. Resident recreation expenditures, on the other hand, represent a part of the current distribution of existing dollars already in the regional economy. Information for the BNF indicated that 57 percent of the visits to the Forest were by local residents with 43 percent being either non- local residents of Wyoming (Wyoming residents from outside the four-county area) or nonresidents of Wyoming (RecNumberCalculation5.xls).

Table B-27 summarizes the per visit trip expenditures estimates used in the analysis. Due to a lack of specific expenditure data for each of the recreation categories reported in the NVUM report, the individual recreation categories were aggregated into the nine expenditure categories listed in Table B-27. These visitor expenditure estimates came from three sources. Hunting and fishing expenditures were obtained from the U.S. Fish and Wildlife Service's 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Wyoming. Snowmobile expenditures were obtained from the Wyoming State Trail Program's Results from 2000-2001 Wyoming Snowmobile Survey. Visitor expenditures for lodging based recreation categories including overnight on the forest, day trips, and overnight off the forest were obtained from Morey & Associates, Inc.'s Report on the Economic Impact of the Travel Industry in Wyoming, 1998. All expenditures were converted to 2002 dollars to be consistent with the IMPLAN models.

Table B-25. Per Person Per Visit Recreation Visitor Expenditures.

	Per Person Per Day	Days/Visit	Per Person Per Visit	Source
Resident Fishing	$35.18	1.31	$46.08	(1)
Non-Resident Fishing	$75.92	2.09	$158.68	(1)
Resident Hunting	$59.89	1.35	$80.85	(1)
Non-Resident Hunting	$116.31	4.37	$508.29	(1)
Resident Snowmobile	$63.42	2.10	$133.18	(2)
Non-Resident Snowmobile	$91.39	4.50	$411.26	(2)
Non-Local Overnight on Forest	$28.27	5.00	$141.36	(3)
Non-Local Day Trip	$33.27	1.00	$33.27	(3)
Non-Local Overnight off Forest	$60.10	4.30	$258.41	(3)

Sources: 1) U.S. Fish and Wildlife Service, 2) Wyoming State Trails Program, 3) Wyoming Business Council, Division of Tourism.

Timber Production Timber harvest from the BNF was based on a five-year average (Thomas_ASQ_TSPQ_Calc_07705.xls). This was done to account for annual variations in timber harvest from the Forest. On this basis it was estimated that the BNF currently produces 1.7 MMBF of sawtimber and 0.2 MMBF of "Products Other Than Logs" (POL). Based on historical data, it was assumed that 2 percent of the sawtimber from the BNF

would be processed on the west side of the mountains 56 percent would be processed on the east side of the mountains, 12 percent would be processed in Park County, Wyoming, and 30 percent would be processed in Montana. For POL, it was assumed that 50 percent would be harvested and processed on the west side and 50 percent would be harvested and processed on the east side of the mountains (Thomas_ASQ_TSPQ_Calc_07705.xls). All timber activity was assumed to involve local logging except for sawtimber going to Park County for processing. These distributions were also used for the analysis of each of the alternatives in the plan.

Due to the price fluctuations associated with lumber products, the economic impact of timber production was based on quantities of timber production. From estimates compiled from various sources by the Forest Service (Bighorn Timber Analysis for FEIS_060605.xls) it was estimated that one MMBF of timber activity by the logging, POL, or the sawmill firms on the west side of the mountains resulted in six direct jobs in the local economy. For the east side, it was assumed that one MMBF of timber activity by the logging or POL firms on the east side of the mountains resulted in 5.9 direct jobs in the local economy. For sawmills on the east side it was assumed that one MMBF of timber production processed by a sawmill resulted in 4.3 direct jobs in the local economy. The employment figures per MMBF are somewhat lower on the east side due to greater efficiency in the timber sector on the east side relative to the west. Estimates of the total employment associated with timber production from the BNF were developed using IMPLAN employment multipliers from the respective models.

Estimates for labor earnings associated with direct employment from timber production on the BNF were based on regional ES-202 data for logging and sawmills in Wyoming. These labor earnings estimates were then adjusted for benefits. For the west side, average earnings per job for logging, POL, and sawmills were estimated to be $24,035. For the east side average earnings per job for logging and POL were estimated to be $29,123, with average earnings per job for sawmills at $38,865. Average earnings per job are lower on the west side than on the east side because the ES202 data indicates earnings for wood products jobs in the Northwest Region of Wyoming are lower than earnings for wood products jobs in the Northeast Region of Wyoming. Estimates of the total labor earnings associated with timber production from the BNF were based on IMPLAN labor earnings multipliers from the respective models.

Livestock Grazing BNF records (2004_1216_BNF_Use_by_CountyM.xls) indicate that there are nearly 114,000 AUMs of livestock permitted on the Forest. Of this total approximately 109,000 are used for cattle and sheep production by ranches located in the four-county area. Of this total one-half of the AUMs were held by ranching operations on the west side of the mountain and one-half were held by ranching operations on the east side of the mountain. Ninety percent of the total AUMs from the Forest were cattle grazing and 10 percent were sheep grazing.

Two budgets were use to estimate cost of production for livestock grazing of ranches holding grazing permits on the BNF. For cattle, a University of Idaho developed budget - Cow-Calf – 500 Cow, Summer on Federal and State Range, Winter Feeding Necessary,

2000 was used in the analysis. For sheep, a budget from a University of Wyoming report - Contributions of Federal Lands to Wyoming Range Livestock Production, 1992 was used in the analysis. Both budgets were adjusted to 2002 dollars to be consistent with the IMPLAN models.

Due to the variability in cattle prices, a ten-year (1994-2003) statewide average value of production was used to value BNF cattle production. This average was estimated from data available in various issues of the Wyoming Agricultural Statistics. The ten-year average value of production for cattle was $35.76. For sheep the 2003 value of production estimated from the Wyoming Agricultural Statistics ($31.58) was used in the analysis.

BNF Operating Budget BNF data (e-mail from Mike Retzlaff 06/29/05) indicates that the 3-year average salary and wage totals for the Forest is $4.5 million. This salary/compensation supports 165 Forest Service employees in the four-county area. Eighty of these workers are permanent employees with 12 located on the west side and 68 located on the east side. Eighty-five of these workers are seasonal employees with 45 on the west side and 40 on the east side. Approximately 20 percent of salary payments go to employees on the west side with 80 percent going to employees on the east side.

Average, non-salary expenditures for the BNF totaled $4.4 million. Based on the distribution of rental expenses on either side of the Forest, it was estimated that 13 percent of these expenditures occurred on the west side of the mountains with 87 percent on the east side. The distribution of these expenditures within IMPLAN was based on the budget object codes provided by the Forest Service (R02_3yr_no_fire.iap).

Comparison or Alternatives and Cumulative Effects

The comparison of alternatives and cumulative effects analysis were based on the above information and BNF estimates of the quantities of commodity outputs by alternative in 2010. 2001 was the base year for the analysis.

Impacts to the local economy from the BNF plan revisions were measured in terms of both employment and labor earnings. Employment was expressed in terms of jobs. A job can be seasonal or year-round and part-time or full-time. In this analysis jobs represent the 12-month average employment and does not consider whether the jobs are part-time or full-time in nature. The income measure used in the analysis is labor earnings. Labor earnings represent both employee compensation (wages and salaries plus benefits) and proprietor income (e.g. self-employed earnings).

Financial and Economic Efficiency Analysis

Financial efficiency is defined as how well the dollars invested in each alternative produce revenues to the agency. Economic efficiency is defined as how well the dollars invested in each alternative produce benefits to society. Present Net Value (PNV) is used as an indicator of financial and economic efficiency.

Quick-Silver, a public domain Windows-based program, was used to discount revenues, benefits, and costs over a 50-year period (2006-2055). A 4% discount rate is specified by agency policy and was used for these analyses.

Revenues from recreation permittee are highly variable and therefore not estimated, except for downhill skiing where historical averages are available. Revenues for grazing are set by law. Sawtimber revenues are shown below and discussed in more detail in the Spectrum model section of Appendix B.

Some economic values are based on actual revenues where markets exist. For timber, these values are based on harvest values by product between 2001 and 2004. For grazing, these values are computed by the Washington Office of the USDA Forest Service and provided to the field on an annual basis. Range values sent to the field in early 2005 are used in these analyses. Values for recreation represent a willingness-to-pay evaluation. These economic values were developed by the SPRA Staff of the Washington Office and updated to current values by the Regional Office of the Rocky Mountain Region. As discussed in the FEIS, willingness-to-pay estimates for non-use values (scenery, existence values, bequest values, etc) have not been established by the agency, and are therefore excluded from this analysis. All values have been adjusted to current dollars. Table B-28 displays the economic values and revenues that were used for each resource.

Table B-26. Economic Benefits and Financial Revenue Values.

Activity	Unit	Economic Benefit	Financial Value
Cross country skiing	RVD	$14	$0
Snowmobiling	RVD	$12	$0
Downhill skiing	Skier-Day	$59	$1
Hunting	RVD	$61	$0
Fishing	RVD	$82	$0
Viewing scenery/wildlife	RVD	$64	$0
OHV use	RVD	$12	$0
Driving	RVD	$12	$0
Developed camping	RVD	$10	$0
Primitive camp/backpacking	RVD	$18	$0
Hiking	RVD	$14	$0
Other	RVD	$14	$0
Grazing – Cattle	HM	$0	$1.79
Grazing – Sheep	HM	$0	$0.36
Grazing – Cattle & Sheep	AUM	$12.47	$0
Timber Harvest - Sawtimber	MBF	$79.87	$79.87
Timber Harvest – POL	MBF	$5.43	$5.43
Timber Harvest - Firewood	MBF	$15.00	$15.00

Detailed costs were not developed for this analysis. Total forest budgets were held constant and assumed to be fully spent for each alternative. An analysis of individual program contributions to benefits, revenues, and costs was not conducted.

Further details of the analysis, such as source references and software, are available in the administrative record.

Recreation Analysis

There were several processes conducted to analyze the issues associated with the recreation management topic. A summary of these processes follows.

Summer ROS Analysis

The recreation opportunity Spectrum (ROS) is a system for classification of outdoor recreation opportunity environments.

In preparation for this analysis, a baseline existing-condition summer ROS map for the Bighorn National Forest was compiled. The map for the existing ROS condition was built using USDA Forest Service, primary base series(PBS) maps built on 7.5 minute USGS quadrangles (1:24000). The original paper maps were drawn on canary tracing paper over PBS maps. Reference maps included: (1) a 1992 ROS map at ½"=1 mile; (2) the forest travel map at ½"=1mile; (3) the 1985 Forest Plan management area map; and (4) paper ortho-photo quadrangles at 1:24000.

ROS mapping is based on a process described in the USDA Forest Service publication, 1986 ROS Book. Most changes from the 1992 inventory of the existing recreation opportunities resulted from refinements based on the more detailed scale of mapping. Changes in the physical and managerial setting as a result of management activities between 1992 and 1998 were considered in mapping the ROS settings.

The summer ROS analysis involved comparing the adopted ROS for each management area by alternative as stated in the recreation guideline for each management area. Adopted ROS composition by alternative was determined by applying the existing Forestwide ROS map to each alternative map of management areas.

The adopted ROS class displays the maximum level of change that an area could experience in terms of ROS criteria over the life of the plan. It is likely that changes to the overall Forestwide ROS "mix" from the current ROS settings will be less extreme since the shift is based on the amount of management that takes place on the Forest. The utility of this analysis is strictly for purposes of alternative comparison.

The summer ROS analysis was mapped based on the following criteria, associated with both the management area's adopted ROS guideline as well as the 1998 ROS inventory.

Table B-27. Management Area and Summer ROS criteria.

MA	Summer ROS criteria
1.11	P
1.13	SPNM
1.2	If existing ROS = P, then P; otherwise ROS = SPNM
1.31	If existing ROS = P, then P; otherwise ROS = SPNM
1.32	If existing ROS = P, then P; otherwise ROS = SPNM
1.33	If within ½ mile of system summer motorized road or trail, then SPM. Otherwise, if existing ROS = P then P; If existing ROS = anything but P then SPNM.
1.5	P
2.1	Based on current ROS.
2.2	If existing ROS = P then P; If existing ROS = anything but P then SPNM.
MW	Based on current ROS and Historical Preservation Plan.
3.24	No change from existing ROS (only found in alt A)
3.31	SPM
3.4	SPNM unless existing ROS = SPM, then it remains SPM
3.5	If existing ROS = SPNM then no change; otherwise ROS = SPM
4.2	If existing ROS = R then it remains R; otherwise RN
4.3	If existing ROS = P, SPNM or SPM then SPM; Otherwise it is RN.
4.4	RN
5.11	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.12	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.13	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.21	No change from existing ROS (only found in alt A)
5.4	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.41	If currently RN then no change. Otherwise SPM.
5.5	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
8.1	RM
8.22	R

Description of abbreviations:

P = Primitive
SPNM = Semi-primitive nonmotorized
SPM = Semi-primitive motorized
RN = Roaded natural
RM = Roaded modified
R = Rural

Forestwide Demand Projections

Future demand was determined by use of a "trends analysis" process. In other words, historic use data (e.g. past changes in the number of recreation visitor days) became predictors of future demand. In the Final EIS, projections were made to 2010.

This sort of analysis has limitations in that it is based on existing recreation activities – it is unable to project "new" recreation activities (a good example of which was the all-terrain vehicle which became popular after the 1985 Plan was completed), it is unable to incorporate potential changes in national or local economics (fluctuations in the prices of gasoline) or the potential for major disturbance events on the Forest, and it does not recognize changes in population demographics (e.g. aging Americans) which are instead addressed in the cumulative effects section.

Historically, the Forest Service has reported visitation not in terms of direct numbers of people who come to the Forest, but in terms of a Recreation Visitor Day (RVD) which is defined as any recreational use on Forest sites which results in 12 visitor hours. For the Final Environmental Impact Statement, the Forest, in consultation with specialists at the regional office and the University of Wyoming, used National Visitor Use Monitoring data for use estimates and projections. The NVUM survey is more credible, from a use statistics standpoint, compared to the old Forest methodology used for the Draft Environmental Impact Statement.

Between October 2000 and September 2001, the National Visitor Use Monitoring Survey was conducted on the Bighorn National Forest. This survey served as the cornerstone for the recreation demand analysis for the FEIS.

The following steps summarize the "trends analysis" process used for the Plan Revision:

1. The Bighorn National Forest worked with Dr. Don English of the U.S. Forest Service's Southern Research Station on determining visitor origin based on survey data – i.e. whether a visitor was a local resident (from the four county area), a nonlocal resident (from Wyoming but outside of the four-county area), or a nonresident (from outside of the State of Wyoming).
2. NVUM data was then categorized into the following activity groups:
    - Cross Country Skiing
    - Snowmobiling
    - Downhill skiing
    - Hunting
    - Fishing
    - Viewing scenery/Viewing
    - OHV use
    - Driving
    - Developed camping
    - Primitive camping / backpacking
    - Hiking
    - Other
3. Once 2001 activity data had been determined by visitor origin, 2010 projections were calculated based on the following parameters:

a. Resident local growth rate was based on the State of Wyoming population growth rate numbers for the east side (Sheridan and Johnson) and west side (Big Horn and Washakie) counties. The 2001 NVUM activity data was first split into east or west and then the corresponding east or west population growth rate was applied. These growth rate numbers came from the 2005 Wyoming Housing Needs Forecast, prepared for the State of Wyoming by Western Economic Services, LLC. East/west activity splits were based on best available information – for example

    i. Snowmobiling – east/west split was based on amount of snowmobile trails by County (east side being Sheridan and Johnson, west side being Big Horn and Washakie);

    ii. Fishing and hunting – east/west split was based on license sales information provided by Wyoming Game and Fish.

    iii. Developed camping – east/west split was based on campground counts for east vs. west counties.

    iv. Dispersed camping – east/west split was based on forestwide dispersed site inventory.

    v. In some instances, where optimal east/west activity split information was not available for an activity (such as "viewing natural features"), the east/west forest acreage ratio was applied.

b. Resident nonlocal growth rate was based on Bowker et al (1999) "Rocky Mountain projections" since it was the most representative of recreation growth rates for the state of Wyoming. Bowker's Rocky Mountain region growth projections were applied to 2001 Bighorn NF NVUM report's resident nonlocal activities and then the east/west split was made.

c. Nonresident growth rate was based on Bowker et al (1999) "Northern projections" since it was the most representative of recreation growth rates for the primary origin of nonresident visitors to the Forest (the upper Midwest). Bowker's northern growth projections were applied to 2001 Bighorn NF NVUM report's nonresident activities and then the east/west split was made.

Effects to Dispersed Camping

Dispersed camping near developed campgrounds

The purpose of the particular effects analysis is to determine the extent of dispersed camping opportunities that will be effected as a result of the following guideline:

"Dispersed camping should not be allowed within ¼ mile of developed campground facilities unless otherwise designated."

The effect of this guideline does not vary by alternative.

While the Bighorn NF is in the process of compiling/assembling GIS data regarding a dispersed campsite inventory, the data layer is not yet complete enough to result in a GIS-based effects analysis which is accurate enough to determine whether or not a particular campsite will be effected by this guideline. While at some later date it might be possible to do a site-by-site GIS analysis, at present the only reasonable factor to use is Forest acres.

Another limitation based on GIS coverage also had to be accounted for. Developed campgrounds were represented by a point and not a polygon in the data layer. As a result, the buffered area (the area which is restricted to dispersed camping) may be very slightly smaller in size than if the GIS coverage included the actual size of the developed recreation site. This was a limitation that had to be worked with but one which should not result in a significant difference in acreage, only several percent, most likely. GIS Analysis determined that the buffered acreage around a single point amounted to 124.3 acres.

Private lands also had to be removed from the acreage base. In addition, existing special orders which prohibit or limit dispersed camping had to be accounted for in the baseline acreage before the actual effects analysis was conducted.

The resulting baseline acreage (before the ¼ mile guideline was applied) was 50,862 acres. To this basemap, the ¼ mile guideline was applied to obtain an acreage effect.

Lake/stream vicinity restriction on dispersed camping

The purpose of the particular effects analysis is to determine the extent of dispersed camping opportunities that will be effected as a result of this standard.

"Prohibit, or mitigate through other management practices, dispersed camping, within 100 feet (or OHWM) of lakes larger than ¼ acre and State listed water quality impaired streams and the mainstem of the 6th level municipal watersheds of Clear Creek, Goose Creek, Tensleep Creek, Shell Creek, and Tongue River."

As with the above analysis pertaining to campground facilities, it was necessary to determine how much acreage is already off-limits to dispersed camping prior to applying this particular standard. While the Bighorn NF is in the process of compiling/assembling GIS data regarding a dispersed campsite inventory, the data layer is not yet complete enough to result in a GIS-based effects analysis which is accurate enough to determine whether or not a particular campsite will be effected by this guideline. While at some later date it might be possible to do a site-by-site GIS analysis, at present the only reasonable factor to use is Forest acres.

The baseline acreage (acreage that is already off-limits to dispersed camping within 100 feet of the above-mentioned waterways) includes the entire Cloud Peak wilderness as a result of an existing special order, private lands, and areas currently under special orders with provisions that are relevant to this standard. The total baseline acreage amounted to 239,901 acres.

To this basemap, the waterway standard was applied to obtain an acreage effect.

Winter Recreation Opportunities

A winter recreation opportunities analysis was conducted which inventoried, by alternative, the amount of acreage open to over-snow motorized travel versus the amount of acreage that would offer a nonmotorized setting.

A baseline map was constructed showing both the Cloud Peak Wilderness as well as winter travel restrictions as a result of special order, travel map provisions (areas designated as "B areas" on the travel map are closed to snowmobile use) and mule deer and elk winter range areas as mapped by the State of Wyoming. Then, by alternative, management areas which effected motorized winter recreation opportunities were quantified. Existing designated Cloud Peak wilderness acres do not vary by alternative and as a result were used as part of the baseline existing condition across all alternatives to show the amount of acreage already closed to winter motorized recreation.

Current base acreage closed to motorized winter recreation amounted to 104,547 acres not including Cloud Peak Wilderness, which when added to the baseline acreage amounts to 296,441 acres, or almost 27% of the National Forest.

Outside of the Cloud Peak Wilderness, the following management areas have prohibitions on winter motorized recreation:

Table B-28. Management Areas with winter motorized prohibitions (outside of Wilderness).

Management Area	Description
1.2	Recommended wilderness
1.31	Backcountry recreation non-motorized use
1.5	Wild rivers
2.2	Research natural areas
5.41	Deer and Elk winter range

The above management areas were compiled by alternative and the net effect on winter motorized/nonmotorized acreage was determined using GIS.

Dispersed Motorized Recreation Effects

A major issue identified during pre-revision scoping activities was the need to restrict motorized travel to designated system routes. As a result, the following standard was adopted by the Forest Leadership Team:

> *"On all lands outside of designated travelways, prohibit motorized travel unless the Forest Visitor Map or a Forest Order indicates that such use is specifically allowed. Allow over-snow vehicle use on snow unless specifically restricted."*

The purpose of the particular effects analysis is to determine the extent of Bighorn National Forest acreage that will be affected as a result of this standard.

Using GIS, the number and size of existing C areas was determined. Total acreage of existing C areas was calculated and percent of affected Forest acreage was calculated.

Wild and Scenic River Analysis

See FEIS Appendix D for a discussion of the Wild and Scenic River analysis process.

Roadless Inventory and Evaluation

Background

The Forest Service is required to inventory, evaluate and consider all roadless areas for possible inclusion in the National Wilderness Preservation System. 36 CFR 219.17 states:

"Unless otherwise provided by law, roadless areas within the National Forest System shall be evaluated and considered for recommendation as potential wilderness areas during the forest planning process…"

Historical Summary

In 1970, the Forest Service studied all administratively designated primitive areas, and inventoried and reviewed all roadless areas in the National Forest and Grasslands greater than 5,000 acres. This study was known as the Roadless Area Review and Evaluation (RARE). RARE was halted in 1972 due to legal challenge.

In 1977, the Forest Service began another nationwide Roadless Area Review and Evaluation (RARE II) to identify roadless and undeveloped areas within the National Forest System that were suitable for inclusion in the National Forest Wilderness Preservation System. RARE II was also challenged in court and it was determined that it did not fully comply with National Environmental Policy Act (NEPA) requirements. The Bighorn NF updated the RARE II analysis during the original Forest Plan analysis, publishing Draft EIS Appendix M in 1983.

Congress passed the Wyoming Wilderness Act of 1984 (PL 98-550) which designated one new wilderness areas on the Bighorn National Forest, the Cloud Peak Wilderness. The Wilderness boundary included the previously existing Cloud Peak Primitive Area, and portions of the Seven Brothers and Cloud Peak Contiguous roadless areas. The Wyoming Wilderness Act also released all remaining roadless areas to multiple use management (Title IV of the Wyoming Wilderness Act of 1984).

Laws, Policy and Direction

Initial authority for roadless inventories and evaluations is based on the Wilderness Act of 1964 (P.L. 88-577). Current direction for roadless area inventories and evaluations is found in 36 CFR 219.17. The primary intent of the evaluation is to consider areas for potential wilderness designation. Further requirements for evaluation of wilderness are

found in FSH 1909.12,7, FSM 1923, and FSM 2320. FSH 1909.12,7 discusses the inventory criteria for roadless areas and their evaluation for wilderness. FSM 1923 is manual direction on wilderness evaluations as part of the forest plan revision process. FSM 2320 is manual direction on wilderness management. Based on the above direction, the region developed a guidance paper entitled *A Roadless and Unroaded Area Inventory, Purpose, Process and Products* (R2 paper) prepared by the Region 2 Planning Analysis Team and Approved by the Regional Directors on 6/4/97 and revised 7/02.

Inventory Process

The first step in the evaluation of potential wilderness is to identify and inventory all roadless, undeveloped areas that satisfy the definition of wilderness found in section 2(c) of the 1964 Wilderness Act.

Section 2 (c) reads: "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is herby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value."

Using the process outlined in the R2 paper as a guide, the undeveloped areas of the forest were identified

- It contains 5,000 acres or more.
- It contains less than 5,000 acres.
    1. It is isolated and of sufficient size to be managed as wilderness.
    2. It is contiguous with an existing wilderness,
    3. It is contiguous with an area of other ownership with wilderness potential,
- It does not contain classified roads[2]

[2] Classified roads are wholly or partially within or adjacent to National Forest System lands that are determined to be needed for long-term motor vehicle access, including State roads, county roads, privately owned roads, National Forest System roads, and other roads authorized by the Forest Service (36 CFR 212.1. Unclassified roads including temporary roads were not excluded from the inventory. Classified roads were buffered by 300 feet.

Areas of improvements with continuing maintenance requirements were generally excluded from the inventory. Map data used to eliminate these areas from the inventory included:

- Timber harvest units, pre-commercial and commercial thinning units
- Reservoirs
- Developed recreation and administrative sites
- Electronic sites
- Utility corridors
- All of the lands that are not part of the National Forest System within the forest boundary.

However, some improvements were included in roadless areas. Examples include motorized trails, range fences, outfitter camps and historic harvest units where activities are no longer evident.

The maps were refined based on the following considerations.

- The definition of wilderness from section 2(c) of the 1964 Wilderness Act which states that areas should have outstanding opportunities for solitude and the imprint of man should be substantially unnoticeable
- The standards from the Recreation Opportunity Spectrum (ROS) for a semi-primitive non-motorized (SPNM) area that states a person should be ½ mile from a road to experience semi-primitive non-motorized opportunities
- The concept of ecological integrity, an area has to be large enough to provide for natural disturbance process without being influenced by the hand of man.
- The idea of practicability in a management sense was included in the Draft EIS roadless inventory. Based upon comments received on the DEIS, review of the Undersecretary of Agriculture's discretionary review of the White River NF Revised Plan appeals, and consultation with Regional Office Staff, this step was omitted from the FEIS roadless inventory. This resulted in an increase of over 100,000 acres of inventoried roadless between the DEIS and FEIS.

The evaluation of the roadless areas for suitability as wilderness is discussed in Appendix C of the Final Environmental Impact Statement.

Water Yield Analysis

This section describes the process used to analyze the probable changes in water yields as a result of vegetation management proposed in the Bighorn National Forest. This analysis was completed to address the issue of whether and how much water yield could be expected as a result of forest management activities. The protocols utilized to estimate water yield changes are all similar for the Arapaho and Roosevelt, Routt, Medicine Bow, and Bighorn Forest Plan revisions.

Water from the Forest is used not only for municipal and agricultural uses but also for instream uses. Streamflow from forested watersheds is primarily a function of total precipitation and losses due to evapotranspiration and groundwater storage. Trees in the watershed affect streamflow by transpiring water, intercepting snow or rain which may be evaporated or sublimated back into the atmosphere, and by modifying the understory's evapotranspiration (Kaufmann et al. 1987). Reductions in forest canopy density results in water being available for streamflow by reducing evapotranspiration and increasing snowpack accumulation into the openings (Alexander et al. 1985). Many experiments have measured changes in streamflow from reductions in vegetative cover on small watersheds, less than a couple square miles (e.g. Bosch and Hewlett,1982). Research on the 6.5 square mile Coon Creek watershed in the Sierra Madre range did not show a significant increase in streamflow until after timber was harvested on 24 percent of the watershed (1.56 square miles or 998 acres) (Troendle et al. 1998).

Precipitation is a primary factor influencing water yield from a basin and the change in water yield caused by vegetation management is also largely determined by the amount of precipitation which occurs on a site. Thus, treatment in spruce-fir yields the greatest change per unit area, because spruce-fir typically occupy the wetter sites. Changes are smaller for treatment of lodgepole pine and smallest for ponderosa pine. Changes in streamflow from vegetation management are not permanent. As an area is restocked and the trees grow, water that was available for streamflow is slowly redirected back to evapotranspiration. Research at the Fraser Experimental Forest indicates that changes in water yield from timber harvest persist at declining levels for approximately 80 years (Troendle and King, 1985).

Information from the Analysis of the Management Situation report (USDA, 1981) shows a baseline water yield of 693,363 acre-feet, for the entire Forest and an existing water yield estimated at 701,286 acre-feet, based on equivalent clearcut area and acres of road. These water yield values were obtained using the HYSED analysis (Silvey and Rosgen, 1980). It is not likely that the alternatives analyzed in detail in this Forest Plan Revision would result in detectable increases in water yields at the Forest scale. The basis for this determination comes from the limited amount of timber harvesting that is being proposed in the action alternatives as compared to that necessary to produce detectable increases in water yield and is supported by modeling on other forests with similar climatic and vegetative conditions.

1. Changes in water yield as a result of alternative vegetation management scenarios were estimated for the Medicine Bow Forest Plan Revision (Chambers 2002). Timber harvest, fuels treatment (prescribed fire and mechanical treatment), wildfire and insect and disease were all analyzed by alternative for changes in water yield. After an exhaustive water yield analysis, they concluded; "*Thus, there would be no significant, measurable local or regional change in water yield from any of the Forest Plan alternatives*."
2. The Medicine Bow National Forest showed average water yield increases in the first decade of Plan implementation from all types of vegetation management. However, total water yield increases did not vary significantly by alternative, presumably as a result of similar reductions in forest canopy cover for all alternatives. The mechanism by which the density of forest cover changes does vary by alternative as management prescriptions tend to emphasize one type of vegetation management over others. The changes in the type of vegetation management tend to compensate for each other in terms of water yield increase. In other words, an alternative with a greater amount of timber harvest tends to have less wildfire, and an alternative with more wildfire tends to have less timber harvest.

   The differences in water yield between alternatives as a result of vegetation management are greatly masked by the comparison to other water quantity values on and downstream of the Forest. The modeled water yield increases that might be generated by any of the alternatives as a result of vegetation management are quite small when compared to the natural average annual water yield at the local watershed (<2%), Forest (<0.2%) and basin-wide scale (<0.1). While real, these projected increased yields are a very small component of the water produced on the Forest, and the difference in water yield between alternatives is even less significant.

   Research from small watersheds shows that approximately 20 – 25 % of the forest cover must be removed to show a measurable on-site increase in water yield. These increased yields are not dependent on a particular silvicultural prescription. Although most water yield studies have been done on small watersheds (e.g. 714 acre Fool Creek on the Fraser Experimental Forest), the Coon Creek experiment on the Medicine Bow National Forest demonstrated that water yields were also shown to increase on this 4,133 acre drainage when it was impacted to the same degree (24 % of the watershed was impacted by road construction or timber harvest) (Troendle at al, 1998). It is reasonable to conclude that these results can be extrapolated to larger watersheds, as long as the entire forested landscape in the watershed is impacted to the same degree.
3. Therefore, to realize measurable increases in water yield from vegetative manipulation on the Bighorn National Forest, approximately 25 % of the forested landscape in the Powder River Basin or the Bighorn River Basin would have to be removed at a given time. The Powder River Basin on the Forest contains 194,264

acres of forested landscape – 25 % of these acres equals 48,566 acres. Recent history shows that only 550 acres of final timber harvest has occurred per year for the last 17 years since the last forest plan revision (2002 Bighorn National Forest Monitoring Report). These acreages are significantly less than those needed to have a measurable effect on water yield at the river basin scale. Large-scale natural events, such as fire, insects, disease or blowdown, may have the potential to reduce forest cover on enough acreage at one time to result in measurable changes in water yield at the Forest or river basin scale. Based on recent history, events of this size are rare on the Forest.

4. Most discussions of potential water yield increases are presented as averages. These average numbers do not represent the actual variability on a monthly or annual basis. Research shows that water yield increases for subalpine landscapes in the Rocky Mountains are limited to the months of spring runoff (typically May or June) and are not present in any other month of the year (Troendle and Nankervis, 2000). Additionally, increases are proportional to the natural precipitation in the basin – i.e. a percentage increase in a flow in a wet year will be a greater absolute increase than a percentage increase in a dry year. A drought will still be a drought, and a flood will be a bigger flood. Rare, large flow events may distort "average" numbers by making them appear higher, but in reality these events are seldom captured or put to beneficial use. The most reliable indicator for water yield from large basins is precipitation, which is fairly constant in the long term. Researchers have not been successful in finding other significant correlations at this scale (Kircher et. al. (1985) discussed in Troendle and Nankervis, 2000).

5. Modeled water yield increases are generally difficult to measure off-site because they are an extremely small fraction of total streamflow. Where water yield increases have been measured on-site, they are undetected in the next larger watershed. The inability to measure these increases off-site, or to measure transmission losses to the point of use, makes it virtually impossible to document the magnitude or persistence of modeled increases in water yields as they are transmitted downstream. Therefore, although we can use models such as WRENNS to estimate theoretical on-site increases in water yield from timber harvest across larger forested landscapes, we cannot track or measure these theoretical increases at the larger scales.

6. Extrapolating the results from small watershed studies to larger basins can easily result in overstated goals and benefits. The realities of fixed and variable constraints such as land ownership, inoperable lands that are too steep, unstable or unproductive, multiple use coordination, water quality or habitat concerns are often left out of analyses that make broad conclusions about possible water yield increases across large landscapes. These practical limitations and resource coordination requirements limit our ability to remove the forest cover from a large portion of the landscape. At Coon Creek, which was set up as a water yield research study, the intent was to harvest one third of the watershed, but other

considerations resulted in only 24 percent of the watershed actually being harvested (Troendle and Nankervis, 2000).

As discussed above water yields that are realized are proportional to precipitation. The largest increases would be predicted to occur in wet years when reservoir storage is least available to capture increased flows.

Maintenance of the increased water yield over time presents an additional operational constraint. Water yield persists over time following vegetation manipulation at a decreasing rate as vegetation grows back to pre-treatment conditions. To continue to realize the increase in water yield, vegetation within the watershed would have to remain in the altered condition. Short of vegetation type conversion, this would require near perpetual manipulation of vegetation over large areas, a near impossible task given the operational constraints noted above.

In the first round of forest planning, Forests had the option to emphasize water yield increases through a specific management area prescription. For Forest Plan Revisions, the Region has elected not to use a specific management area prescription for water yield emphasis in light of the scientific and operational constraints discussed above and experience in implementing current Forest Plans. Regional policy is that modeled water yield increases will be a result of normal timber management and fuels reduction prescriptions rather than an output of forest management.

7. Technical, social, political, operational and legal constraints of increasing water yields through forest management have been well documented (e.g. Troendle and Nankervis, 2000; Ziemer, 1987; Ponce and Meiman, 1983). Most beneficial uses of water, such as fish-bearing streams or diversions for agriculture, occur at locations where water yield changes due to vegetation management on the Forest are unlikely to be measureable. While real, these increased yields do not contribute significantly to beneficial uses at the local level or to enhanced wildlife habitat in downstream habitats.

Based on the above discussion, it is unlikely that there will be any detectable increase in water yields as a result of the proposed alternatives.

Biological Diversity Analysis

Forest Vegetation Simulator The primary tool used for estimating growth of forest stands was the Forest Vegetation Simulator (FVS) {Wycoff 1986, Wycoff *et al.* 1990, Teck 1996}. FVS is an individual-tree, distance-independent, growth and yield model. It has its structural roots in the Stand Prognosis Model developed by Albert Stage from the Intermountain Research Station {Stage 1973}. Staff at the USFS Forest Management Service Center in Fort Collins have now calibrated a variant of this model for the Central Rockies geographic area {Dixon 2001}. FVS extensions were also used to allow modeling of canopy cover {Crookston and Stage 1999, Crookston 1985, 1990}.

The results of FVS modeling were incorporated into:

- Growth and yield information for inclusion in the *Woodstock*© modeling of timber harvest;
- Determining residence times for structural stages for successional stage modeling.
- Determining fire regime and condition class, and crown bulk density, used to calculate fire risk and hazard.

FVS allows the user to calculate estimates of forest stand structure and species composition over time and quantify this information to (1) describe current and future forest stand conditions, (2) simplify complex concepts of forest vegetation into user-defined indices, attributes, etc., and (3) allow the manager to ask better questions about growth and yield of forested stands and complete analyses to answer those questions.

The FVS model structure contains modules for growing trees; predicting mortality; establishing regeneration; simulating growth reductions, damage, and mortality due to insects and disease; performing management activities; calculating tree volumes; and producing reports. One of the strengths of the FVS system is its ability to incorporate local growth rate data directly into the simulation results.

FVS information for *Woodstock*© used actual forest stand data selected from the Forest's IRI database to project growth and yields for future outputs. FVS information for other applications modeling regeneration from bare ground using average forest parameters (elevation, aspect, stocking, species representation) by cover type.

Forest Successional Stage Modeling Structural stages are used for a variety of forested land analysis. FVS modeling was used for structural stage development in the lodgepole, spruce/fir and Douglas fir cover types. Because there were no FVS runs for non-commercial species, to model the successional path of these cover types the Forest used a local successional stage development model created for the 1994 ASQ analysis. For these cover types, vegetation development followed a pathway based upon basic successional processes. Natural disturbances included wildland fire; insect and disease events were not included because of the random, stochastic nature of these events.